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MONITORING, STREAMLINING AND REORGANIZING WORK WITH DIGITAL TECHNOLOGY

A case study on software for process mining, workflow automation, algorithmic management and AI based on rich behavioral data about workers

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Contents

Summary

Data collection in the workplace has become ubiquitous. Employers use a growing number of information systems to plan, organize and manage workflows and work performed by their employees, most prominently systems for enterprise resource planning (ERP) and customer relationship management (CRM), which are now used by mid- to large-size organizations in most industries. Many systems constantly store digital records about work activities and behaviors of employees. This data is increasingly stored in centralized databases and in the cloud. Employers exploit the data to support managerial decisions, organize work, automate workflows and monitor workers. The technical systems in place are often complex and opaque. Most workers will not be aware of the data flows and decisions that occur in the background while they routinely interact with networked software and devices at work.

This case study explores, examines and documents software systems and technologies used by employers that utilize extensive personal data about the work activities and behaviors of employees to streamline, reorganize and manage work, expand control over workers, subject them to digital monitoring and make automated decisions about them – with a focus on Europe. To illustrate wider practices, it investigates cloud-based software for enterprise data analytics, workflow automation and algorithmic management provided by the German vendor **Celonis**, based on a detailed analysis of software documentation and other corporate sources.

Celonis is considered the global market leader in software for **process mining**, which utilizes activity log data recorded by enterprise systems from vendors like SAP, Oracle, Salesforce and Microsoft to create a digital representation of how work is actually being performed in an organization, down to granular steps and tasks. Process mining aims to analyze, standardize and optimize workflows in order to make them more productive and efficient while lowering costs. Still considered a "startup", Celonis has a significant customer base in Europe and the US. It received more than a billion in venture capital and was listed among the five largest private investments in "AI" technology globally in 2022. SAP started reselling its technology in 2015. Since then, Celonis has added functionality for workflow automation and task management and started to refer to its technology as an "execution management system", putting the focus on managing rather than merely analyzing work. Several consulting firms like KPMG, Deloitte, Accenture, Capgemini, IBM and the Porsche subsidiary MHP provide Celonis-based applications.

This case study documents a wide range of data practices, which can **affect workers in many fields**, from insurance claim handling to manufacturing, from creative work to warehouse picking, from low-wage to knowledge work:

- **Analyzing extensive personal data.** Celonis analyzes large amounts of log data about work activities recorded by ERP, CRM and other enterprise software systems. This can occur in real time and include millions of time-stamped activity records that typically contain personal data about the workers who perform the activities.
- **Streamlining, reorganizing and managing work.** Based on the data, Celonis evaluates, assesses and monitors workflows in many industries in order to optimize them in line with the employers' business goals. Metrics about productivity, time, quality, automation and cost are ubiquitous. Several mechanisms help to automate the reorganization and management of work. The "process AI" promises to identify the "root causes" for "undesired activities" and other inefficiencies. The system can also notify managers of deviations from KPI targets and assign them tasks. The "simulation" module forecasts and predicts the impact of process changes.
- **Group-level digital control.** The analysis of workflows, activities and metrics for groups, such as teams, departments, units, offices, plants or subcontractors, plays a major role. The system lets employers drill down into group data and compare different groups. Group-level analysis can facilitate internal competition and

represents a form of performance monitoring for managers, who are expected to pass the pressure on to workers. It can also facilitate peer control, where members of a team or other groups put pressure on each other.

- **Granular performance and behavior monitoring.** Celonis' technology can be used to scrutinize work at the level of individual employees and monitor, rate and rank named workers by their productivity, speed, work outcomes and behaviors. Employers can use it for granular performance and behavior monitoring, from rating what call center agents say in conversations to assessing tasks down to the second in manufacturing.
- **Analyzing social interactions.** Another software module "adds the social aspect of processes" to the system and promises to assess work activities with respect to social interactions and collaboration between workers.
- **Workflow automation across enterprise systems.** In addition, the system can facilitate workflows and real-time data sharing across Celonis' process mining software and hundreds of other enterprise systems, such as for ERP, CRM, HRM, task management and communication. It can automatically initiate particular actions in SAP, Salesforce, Workday or Microsoft 365 when certain criteria are met in the process data. It can also trigger actions based on networked access to other enterprise systems, for example, by watching the location of a delivery driver or by monitoring the corporate chat system Slack or an Outlook email inbox.
- **Automated task assignment.** Celonis' workflow automation technology can involve processing workers' personal data and making automated decisions about them. It can automatically prioritize, distribute and assign tasks to workers and provide them with a limited set of recommended actions to perform.
- **Apps that combine process analysis and algorithmic management.** Employers, consulting firms and other vendors can create Celonis-based applications that address particular processes in an organization. These apps can combine process analysis, management automation, workflow automation and task assignment.
- **Recording screen, application, browser, keyboard and mouse activity.** Another Celonis technology analyzes interactions, behaviors and activities performed on the desktop computers of employees. The "task mining" system can capture extensive personal data including screen recordings, keystrokes, mouse clicks and clipboard contents from up to 2,500 employees. While employers can customize the captured data, example applications show that the system can be used to scrutinize how workers use programs and applications, websites, keyboard commands and copy/paste functionality. Employers can combine data on desktop interactions with activity data from enterprise systems and use it to detect "inefficiencies", decrease the time spent on "non-value adding activities" and assess "workforce productivity", "productive time" and "idle time". Corporate sources suggest that analysis results can be displayed both at the level of teams and for individual workers.

Employers can customize the systems offered by Celonis and its partners, use only parts of them or use them in less intrusive ways. The last section of the case study summarizes the identified data practices and discusses potential **implications for workers**. While granular performance monitoring at the individual level is clearly problematic, extracting aggregate knowledge from personal data increases the power imbalance at work and can also have significant effects. Utilizing the data to standardize and unilaterally reorganize workflows can accelerate and intensify work, reduce discretion, make workers easier to replace, facilitate outsourcing, undermine bargaining power and affect wages. Employers may refer to "objective" data to justify arbitrary decisions. Automated task assignment and algorithmic management practices can also have a variety of side effects. The rapid expansion of data flows and functionality potentially undermines purpose limitation, a cornerstone of European data protection law.

The findings of this case study will be incorporated in the main report of the ongoing project "Surveillance and Digital Control at Work" (2023-2024), led by Cracked Labs, which aims to explore how companies use personal data on workers in Europe. The main report will draw further conclusions.

1. Introduction, background and overview

This case study explores, examines and documents how employers can utilize software to analyze large amounts of personal data about the activities and behaviors of employees to streamline and reorganize work according to their business goals, expand control over workers, subject them to extensive digital monitoring and make automated decisions about them – with a focus on Europe. To illustrate wider practices, it investigates software for enterprise data analytics, workflow automation and algorithmic management provided by the German vendor Celonis. This software potentially affects workers in many industries and areas of work, from insurance claim handling to manufacturing, from creative work to warehouse picking, from call center work to quality assurance, and from low-wage to knowledge work.

Many of the data practices examined in this case study, such as process optimization, automated decision-making and algorithmic management, are usually discussed under the umbrella terms "artificial intelligence" and "AI" (Lane and Williams, 2023; AI HLEG, 2019). This publication largely avoids these terms because of their obfuscating ambiguity (Tucker, 2022) and instead tries to be specific about the technologies in question.

This initial section presents a review of the developments, technologies and systems that are relevant to this case study, followed by a short profile of the German enterprise software vendor Celonis and an overview of the case study.

1.1 Log data, process mining, workflow automation and task management

Data collection in the workplace has become ubiquitous. A rapidly growing number of companies and other organizations use a wide range of information systems that record data about the work activities and behaviors of employees across the entire day. Many software systems, applications and devices in the workplace store digital records on an ongoing basis. Employers use this recorded data to monitor behavior, assess performance and, increasingly, to direct tasks, manage workers and make automated decisions about them. More broadly, they exploit large amounts of data to unilaterally reorganize and reshape work. This can deeply affect employees' working conditions, wellbeing, rights and bargaining power. The technical systems in place are often complex and opaque. Many workers might not even be aware of the data flows that occur in the background while they routinely interact with applications, devices, environments and other networked technologies in the workplace (Christl, 2021).

Enterprise software systems. In the last few decades, most medium- to large-sized organizations have started to use comprehensive software and information systems to plan, manage and control operational processes and workflows, most prominently systems for enterprise resource planning (ERP). These systems are now used across every sector and industry, including in manufacturing, retail, logistics, telecommunications, finance, healthcare and even education (Shehab et al., 2004). ERP systems shape organizational procedures and workflows and thus deeply affect everyday work (Kallinikos, 2011). The global market leader has long been the German company SAP, followed by other major enterprise software vendors such as Oracle, Sage, Infor and Microsoft.[1]

[1] See e.g. Forrester (2004): ERP Applications-Market Maturity, Consolidation, and the next generation, Forrester Research, 2004; Gartner (2019): Market Share: Enterprise Resource Planning, Worldwide, 2018. Gartner, 16.4.2019

Several other types of enterprise software play a similar role in certain business areas. For example, customer relationship management (CRM) systems such as Salesforce and Microsoft Dynamics[2] help manage work activities and tasks that involve getting in touch with customers or clients. CRM systems are now used to organize and manage diverse types of work ranging from sales, order management and customer support (Torggler, 2008) to technical maintenance (Kristiansen et al., 2018) and healthcare (Baashar et al., 2020). ERP and CRM systems are just two examples of comprehensive enterprise information systems, albeit among the most relevant, because they cover many business activities and are typically connected to several other systems at work (Christl, 2021).

Analyzing activity and event log data. Software systems for ERP and CRM have in common that they constantly store digital records on work activities and steps in activity, transaction or event logs. Each log record typically contains information about the type of activity performed, a timestamp that reflects when it was performed and information on the object or subject of the activity, which is often referred to as a "case", for example a customer order or a unit in a manufacturing process. In addition, log records often contain information about the employee who carried out the activity (Selig, 2017). An activity log may, for example, contain records about a customer order ("case") that was received, dispatched to the warehouse, picked, packed, shipped, invoiced and paid. Organizations increasingly combine activity log data from different enterprise systems. They store it in centralized databases, a practice often referred to as **data warehousing** (Sen and Sinha, 2005), and then use a broad range of technologies to analyze the data and extract knowledge from it in order to make managerial decisions that support their business objectives, a practice often referred to as **business intelligence** (Ul-Ain et al., 2019).

"Process mining" and optimization. Process mining, a specific form of enterprise data analytics, aims to analyze processes and workflows based on log data records from different systems that reflect actual activities, workflow steps and tasks (Aalst, 2012; Claes and Poels, 2014; Selig, 2017). Leading vendors that provide software for process mining include Celonis, Software AG, SAP, Microsoft and IBM. The controversial firm Palantir also offers a process mining system.[3] According to the market research firm Gartner, the German vendor Celonis has "dominated the market since its commercialization". Its current global market share is estimated at more than 60%.[4] According to Wil van der Aalst, a Dutch computer scientist and "chief scientist" at Celonis,[5] process mining "aims to discover, monitor, and improve real processes by extracting knowledge from event logs readily available in today's information systems" (Aalst, 2012).

As this case study shows,[6] process mining is typically utilized to optimize, streamline and reorganize workflows and work activities according to certain business objectives, such as increased efficiency and lower costs. This technology can affect workers in many industries and areas of work, from insurance claim handling to manufacturing, from creative work to warehouse picking, from IT service management to call center work, from low-wage to knowledge work. Celonis, the market leader, has added several features to its process mining system over the years including functionality that can be considered algorithmic management and "artificial intelligence".[7]

[2] See e.g. Gartner (2021): Magic Quadrant for the CRM Customer Engagement Center, Gartner 15.6.2021; IDC (2022): European CRM Application Market Shares, 2021: Salesforce Dominates While Microsoft Climbs, IDC study, June 2022.
[3] https://www.palantir.com/platforms/foundry/process-mining/ [2.8.2023]
[4] Gartner (2023): Magic Quadrant for Process Mining Tools. Gartner, 20.3.2023
[5] https://www.vdaalst.com/ [2.8.2023]
[6] See sections 2, 3 and 4.
[7] Ibid.

Business process and workflow management. The analysis and optimization of operational processes can be seen as part of a broader discipline referred to as business process management (BPM), which aims to achieve an organization's objectives through the "improvement, ongoing performance management and governance of essential business processes" (Jeston, 2018). Several decades old, BPM is rooted in traditions from both management sciences and information technology. Paul Harmon (2010) traced BPM back to traditions of work simplification, industrial engineering and quality control (e.g. Taylorist "scientific management", Ford's assembly line, "total quality control", "lean manufacturing", "Six Sigma"), management traditions that focus on the overall performance of a firm (e.g. "value chains", "balanced scorecard") and information technology traditions (e.g. "business process reengineering", "expert systems", "decision management", "enterprise resource planning").

According to Wil van der Aalst (2013), BPM has a broad scope ranging from process analysis and automation to workflow management, operations management and work organization at large. A **workflow** has been defined as a "collection of coordinated tasks designed to carry out a well-defined complex process" (Haller et al., 2005). The terms "process" and "workflow" are, however, often used interchangeably (see e.g. Ruecker, 2021).

Workflow automation and task management. The boundaries between the terms "management" and "automation" are blurred as well. A typical workflow management system in the 1990s was centered around task management for human employees (Ruecker, 2021). It distributed and routed work items, such as a consumer's application to open a bank account, to particular employees according to certain rules. Depending on the outcome of the task, the work item got routed to another employee, once again according to certain rules, and so forth (see e.g. Kumar et al., 2002). Routing work items to particular employees according to certain rules can already be considered a form of "automation". As soon as the decision occurs without the involvement of a human, for example, by a computer system that automatically routes the application to open a bank account to a particular department or employee, this certainly represents what is commonly understood to be workflow automation. Not every step in a workflow necessarily involves the assignment of a task to an employee. Workflow technology has long been part of ERP and other enterprise software systems (Kumar et al., 2002). As this case study shows,[8] the process mining vendor Celonis also provides functionality to automate workflows and task assignment.

Workflow automation across cloud-based enterprise systems. In the age of networked communication, service-oriented architecture[9] and cloud computing,[10] enterprise software that is provided as a cloud-based service, rather than operated by the employer in their own data center, has become the norm. Software that is provided as a cloud-based service can usually be easily integrated with other cloud-based services, for example, via APIs[11] that enable the networked expansion of data flows and functionality across different software systems (Gürses and Van Hoboken, 2018). A number of vendors provide systems that promise to help connect and integrate different cloud-based enterprise software systems with each other, either to let one system simply access data or functionality from another system or to automate workflows across systems. The industry uses several marketing terms to describe systems with sometimes overlapping functionality, such as "digital process automation", "intelligent

[8] See section 6
[9] See e.g. https://en.wikipedia.org/wiki/Service-oriented_architecture
[10] See e.g. https://en.wikipedia.org/wiki/Cloud_computing
[11] See e.g. https://en.wikipedia.org/wiki/API

business process management", "enterprise integration platform as a service" or "low-code application platform".[12] Major vendors include SAP, Oracle, Microsoft, Informatica, TIBCO, Pegasystems, Appian, Salesforce and ServiceNow.[13] Most of them now provide functionality for "low-code" development, which enables business analysts, managers and other non-programmers to rapidly build automated workflows and data integrations across enterprise systems without much coding, based on visual environments that make it possible to create applications by combining models, components and other abstractions.[14] As detailed in this case study,[15] the process mining vendor Celonis also provides functionality for workflow automation across enterprise systems.

Analyzing screen, keyboard and mouse interactions on desktop computers. Several process mining vendors do not stop at the analysis of extensive personal data about work activities based on activity logs from enterprise systems, but also provide software that records behavioral data on employees' use of desktop computers. The market research firm Gartner explains that process analysis cannot capture "desktop-level tasks", which is a "shortcoming" that can be addressed through so-called "**task mining**" software.[16] Vendors include IBM, Microsoft and Celonis, the latter of which is investigated further in this case study.[17] Task mining can involve capturing screen recordings and data on application use, keyboard activity and mouse clicks. Gartner suggests that employers could use task mining for "task discovery and analysis" and to optimize "workforce productivity", among others. It could also "identify risky behavior by employees and any misuse of workplace applications".[18] Task mining can also be used to implement and monitor systems for "robotic process automation" (RPA) such as Automation Anywhere,[19] which help to automate the use of older programs based on automated interactions with their graphical user interfaces.[20]

1.2 The process mining and workflow automation vendor Celonis

This case study investigates software for the analysis, optimization and management of processes, workflow automation, automated task assignment, system integration and task mining provided by the German vendor Celonis, which was selected as an illustrative example of wider practices for three reasons. First, it is considered the global market leader in software for process mining,[21] a form of enterprise data analytics that has become relevant over the last decade. Second, it offers a number of additional systems that are integrated with its process mining software. Third, Celonis provides comprehensive software documentation[22] and other sources[23] online.

[12] See e.g. Ruecker (2021); Gartner (2021): Magic Quadrant for Enterprise Integration Platform as a Service. Gartner, 29.9.2021; Gartner (2022): Magic Quadrant for Enterprise Low-Code Application Platforms. Gartner, 31.12.2022
[13] Gartner (2019): Magic Quadrant for Intelligent Business Process Management Suites. Gartner, 30.1.2019; Forrester (2021): The Forrester Wave: Digital Process Automation Software, Q4 2021. Forrester, 14.12.2021; Gartner (2021): Magic Quadrant for Enterprise Integration Platform as a Service. Gartner, 29.9.2021; Gartner (2022): Magic Quadrant for Enterprise Low-Code Application Platforms. Gartner, 31.12.2022
[14] See e.g. https://www.gartner.com/reviews/market/enterprise-low-code-application-platform
[15] See section 6
[16] Gartner (2022): Market Guide for Task-Mining Tools. Gartner, 28.4.2022.
[17] See section 5
[18] Ibid.
[19] Forrester (2023): The Forrester Wave: Robotic Process Automation, Q1 2023. Forrester, 28.2.2023
[20] See also section 6.2
[21] See section 1.1
[22] https://docs.celonis.com/ [2.8.2023]
[23] e.g. https://www.youtube.com/@CelonisPM/videos [2.8.2023]

Celonis. Almost unknown to the broader public, the German software company Celonis has become a large player in the world of enterprise data analytics in recent years. It promises to help businesses and other organizations analyze their operational processes and workflows in order to optimize them, with a strong focus on making them more efficient, increasing productivity and lowering costs.[24] Founded as a startup at the Technical University of Munich in 2011, Celonis received $27.5 million of funding in 2016, $50 million in 2018, $290 million in 2019 and $1 billion each in 2021 and 2022 from US venture capital firms, investment firms and the Qatar Investment Authority.[25] As such, Celonis was listed among the global "top five AI private investment activities" in 2022.[26] In 2015, the German enterprise software giant SAP started reselling[27] Celonis' software, branded as "SAP Process Mining by Celonis".[28] The company opened a second headquarters in New York City in 2017, and is now headquartered both in Germany and in the US, with 3000 employees.[29]

Customers. According to Celonis, its customers include many large firms and global players in Europe, the US and other regions – in manufacturing (Siemens, ABB, Bosch, BMW, Porsche, Zeiss, Honeywell, 3M, Airbus),[30] banking (Deutsche Bank, UniCredit, Santander, HSBC),[31] insurance (Zurich),[32] consumer goods (Nestlé, L'Oréal, PepsiCo, Heineken, Anheuser Busch, Hugo Boss),[33] retail (Asos, Zalando, Edeka),[34] technology (Cisco, HP, Dell, Huawei, Uber),[35] telecommunication (Deutsche Telekom, Vodafone),[36] pharma (Johnson & Johnson, GSK),[37] healthcare technology (GE Healthcare, IQVIA)[38], oil and gas (BP, TotalEnergies, Petrobras, Repsol, Phillips 66),[39] utilities

[24] According to Google search results and as of 23.4.2023, the celonis.com website includes 398 pages that contain the phrases "increase efficiency", "improve efficiency", "boost efficiency" or "efficiency gains", 204 pages that contain the phrases "increase productivity", "improve productivity", "boost productivity", "drive productivity" or "productivity gains", as well as 402 pages that contain the phrases "lower costs", "cut costs", "cutting costs", "reduce costs", "reduce cost" or "reducing costs".

[25] Celonis website: https://www.celonis.com/company/ [23.4.2023]; Technical University of Munich website: https://www.mgt.tum.de/our-stories-with-impact/stories/dies-academicus-2021-tum-honors-school-of-management-alumni-and-affiliate-professor [23.4.2023]; Metinko, Chris (2022): Celonis Raises $1B In Funding At $13B Valuation. Crunchbase, 23.8.2022. Online: https://news.crunchbase.com/web3/celonis-raises-1billion/; Levingston, Ivan; Tan, Gillian; Roof, Katie (2022): Qatar Wealth Fund Invests in Celonis at $13 Billion Valuation. Bloomberg, 23.8.2022. Online: https://www.bloomberg.com/news/articles/2022-08-23/qatar-leads-investment-round-in-celonis-at-13-billion-valuation; Konrad, Alex (2021): Celonis Raises $1 Billion At $11 Billion Valuation, Making It New York's —And Germany's — Most Valuable Startup. Forbes, 2.6.2021. Online: https://www.forbes.com/sites/alexkonrad/2021/06/02/celonis-process-mining-raises-at-11-billion-valuation

[26] Stanford University (2023): Artificial Intelligence Index Report 2023, AI Index Steering Committee, Institute for Human-Centered AI, Stanford University, Stanford, CA, April 2023. Online: https://aiindex.stanford.edu/wp-content/uploads/2023/04/HAI_AI-Index-Report_2023.pdf

[27] Schlenk, Caspar Tobias (2015): Per Bootstrapping zum globalen SAP-Partner. Gründerszene, 17.9.2025. Online: https://www.businessinsider.de/gruenderszene/allgemein/celonis-partner-sap/

[28] https://help.sap.com/docs/SAP_PROCESS_MINING_BY_CELONIS [23.4.2023]

[29] https://www.celonis.com/company/ [2.8.2023]

[30] https://www.celonis.com/solutions/industries/manufacturing/, https://www.celonis.com/press/reuters-german-data-mining-software-provider-celonis-valued-at-2-5-billion-after-funding-round [15.5.2023]

[31] https://www.celonis.com/solutions/industries/banking/ [15.5.2023]

[32] https://www.celonis.com/press/zurich-insurance-group-selects-celonis-to-accelerate-digital-transformation-and-improve-customer-experience [15.5.2023]

[33] https://www.celonis.com/solutions/industries/cpg/, https://www.celonis.com/press/celonis-presents-and-exhibits-at-shared-services-outsourcing-week, https://www.munich-startup.de/57784/celonis-one-world-trade-center/, https://www.celonis.com/customers/ [15.5.2023]

[34] https://www.celonis.com/solutions/industries/retail/ [15.5.2023]

[35] https://www.celonis.com/de/customer-success-stories/cisco-customer-service-process-mining/, https://www.celonis.com/solutions/industries/high-tech/ [15.5.2023]

[36] https://www.celonis.com/solutions/industries/telco/ [15.5.2023]

[37] https://www.celonis.com/solutions/industries/life-sciences/ [15.5.2023]

[38] https://www.celonis.com/solutions/industries/life-sciences/, https://www.celonis.com/customer-success-stories/iqvia-shared-service-centre/ [15.5.2023]

[39] https://www.celonis.com/solutions/industries/oil-gas/ [15.5.2023]

(E.ON)[40] and air travel (Lufthansa).[41] The company also states that it serves "global healthcare leaders"[42] and the public sector.[43]

On its website, Celonis provides a number of "customer stories", which boast about how the company helped customers to reduce costs by 40% (IQVIA),[44] found "a billion dollars worth of cashflow opportunity" (HP)[45] or increased "throughput time" by 30% (the German manufacturer Eissmann).[46] Other sources contain quite detailed information about the practical use of Celonis' technology at particular customer companies or consulting partners (e.g. Koch Industries, Deloitte).[47] Celonis claims that more than 2,000 **consulting firms** use its technology for client projects, including the major players KPMG, PwC, EY, Deloitte, Accenture and IBM.[48] In addition, Celonis serves large **business process outsourcing (BPO)** firms with hundreds of thousands of employees, who handle all kinds of outsourced work on behalf of other companies (Christl, 2023), for example, Cogizant, Wipro and Accenture.[49]

1.3 Overview of the case study

This case study explores software for data analytics, workflow automation and algorithmic management provided by Celonis, which was selected as an illustrative example of wider practices, with a focus on how these systems process personal data on workers. Building on previous German-language research (Christl, 2021) and a literature review, it aims to identify, examine and document data practices that affect workers, based on an analysis of publicly available corporate sources such as software documentation, training videos and marketing materials.

- **Section 2** explores how Celonis' software for "process mining" can be used to analyze large amounts of log data about work activities from different enterprise systems to optimize workflows in line with the employer's business goals. The system evaluates and assesses workflows down to granular tasks, their durations and outcomes, from insurance claim handling to warehouse management. It extracts knowledge from activity data and calculates performance metrics for teams, departments and other groups. The "process AI" automatically identifies possible "root causes" for "undesired activities" and other inefficiencies. As **section 3** shows, Celonis has recently started to refer to its software as an "execution management system", putting the focus on managing rather than merely analyzing work. Its cloud-based system has turned into a platform that lets third-party vendors create Celonis-based applications, which combine process analysis and optimization with workflow and management automation. Additional software modules help to automate the reorganization and streamlining of work towards KPI targets and to simulate, forecast and predict the impact of process changes.
- While the system can be used without disclosing personal data in analysis results and reports, **section 4** documents examples that systematically expose information about named workers, from IT service management to manufacturing to creative work. Most examples examined in this section refer to Celonis-based applications provided by third-party firms, such as KPMG or the Porsche subsidiary MHP. They show that Celonis'

[40] https://www.munich-startup.de/57784/celonis-one-world-trade-center/ [15.5.2023]
[41] https://www.celonis.com/de/customer-success-stories/lufthansa-customer-service-process-mining/ [15.5.2023]
[42] https://www.celonis.com/solutions/industries/healthcare-providers/, https://www.celonis.com/solutions/industries/healthcare-payors/ [15.5.2023]
[43] https://www.celonis.com/solutions/industries/public-sector/ [15.5.2023]
[44] https://www.celonis.com/customer-success-stories/iqvia-shared-service-centre/ [15.5.2023]
[45] https://www.celonis.com/customer-success-stories/hp-execution-excellence-process-mining/ [15.5.2023]
[46] https://www.celonis.com/customer-success-stories/eissmann-procurement-production-process-mining/ [15.5.2023]
[47] https://www.youtube.com/watch?v=DT4P48WLDdY, https://www.youtube.com/watch?v=tRTmYTiqzJ0 [15.5.2023]
[48] https://www.celonis.com/solutions/celonis-for-consulting/ [15.5.2023]
[49] https://www.celonis.com/solutions/bpo/ [15.5.2023]

technology can be used to analyze work activities performed by individual employees, compare workflows between individuals and display metrics about "employee productivity", their speed of work, work outcomes and behaviors at the individual level. Employers can use this information for granular performance and behavior monitoring, from assessing task performance down to the second in manufacturing to rating what call center agents say in conversations. Celonis also offers the ability to analyze social interactions and collaboration between employees, both for groups and for individuals, as the documentation suggests. While some examples examined in section 4 may display personal data about employees for legitimate purposes, several examples can be considered disproportionate or highly intrusive.

- **Section 5** investigates an even more intrusive system provided by Celonis. Its "task mining" software analyzes interactions and work activities performed on employees' desktop computers. It can record extensive personal data about screen, application, browser, clipboard, keyboard and mouse activity. Celonis suggests combining the captured data with log data from enterprise systems and provides functionality to analyze the behaviors of employees, such as the programs used, websites visited, copy and paste activity, the occurrence of keyboard commands and the duration of activities like "writing". Employers can use it to detect "inefficiencies", decrease the time spent on "non-value adding activities" and assess "workforce productivity" by calculating "productive times" and "productivity scores". While the latest software version displays analysis results at the level of teams and other groups only, earlier versions appeared to display this information at the level of individual employees. A third-party application based on Celonis' task mining system provided by IBM, for example, displays individual-level data on desktop interactions, work activities, "user level effort" and "idle time". Employers can generally limit the captured data categories, obfuscate text and communication contents to some extent and exclude programs from being tracked.
- In addition to process analysis and optimization, Celonis provides extensive functionality for workflow automation and automated task assignment, as examined in **section 6**. The system can facilitate workflows and data sharing across Celonis' process mining software and hundreds of other enterprise systems, such as for ERP, CRM, HRM, task management, communication and collaboration. It can automatically initiate particular actions in SAP, Salesforce, Workday or Microsoft 365 when certain criteria are met in the process data. It can also trigger actions based on real-time access to other enterprise systems, for example, by watching the location of a delivery driver or by monitoring corporate chat systems or email inboxes. This can involve processing personal data about employees and making automated decisions about them. The system can automatically prioritize, distribute and assign tasks to workers and provide them with a limited set of recommended actions to perform. Both workflow automations and the built-in task management system can be part of Celonis-based applications that manage and "orchestrate" particular processes in an organization.

The investigation identifies a wide range of mechanisms and data practices that affect workers. **Section 7** summarizes and reflects on the findings and presents a classification of data practices that distinguishes the identified mechanisms with respect to how they process personal data. A number of mechanisms expose personal data about workers in their output, single workers out, profile them or make decisions about them. Other mechanisms that rely on the analysis of extensive personal data without exposing it in their output can also have significant effects on employees. Extracting knowledge from personal data about work activities at scale increases the power imbalance between workers and employers. As outlined in section 7, utilizing the data to streamline and reorganize work can lead to an acceleration and intensification of work, reduce workers' bargaining power, make them easier to replace, facilitate outsourcing and lead to lower wages. Group-level metrics can facilitate peer control and represent a form of performance monitoring for managers, who potentially pass the pressure on to workers.

1.4 Context, scope and limitations

This case study is part of a series of case studies on systems that process data at the workplace, which are, in turn, part of the **ongoing project**, "Surveillance and Digital Control at Work",[50] led by Cracked Labs. The project aims to explore how companies use personal data on and against workers in Europe, together with AlgorithmWatch, Jeremias Prassl (Oxford), UNI Europa and GPA, funded by the Austrian Arbeiterkammer. The case studies build on **previous research** on the topic (Christl, 2021). They aim to document technologies and data practices by reviewing existing literature and by **examining technologies and software systems** that are available on the market based on publicly accessible vendor information. This includes software documentation and marketing materials, which might be ambiguous and incomplete. Every effort has been made to accurately interpret these corporate sources, but we cannot accept any liability in the case of eventual errors. Where the case studies rely on the examination of corporate sources, it remains largely unclear how employers actually implement, customize and use the functionality provided by these systems. The findings of the case studies will be incorporated into the **main report** of the ongoing project, which will draw further conclusions from the findings.

[50] https://crackedlabs.org/en/data-at-work

2. Analyzing and optimizing processes and work activities

This section gives an initial overview of how organizations can use Celonis' software to document, analyze, standardize, optimize and monitor operational processes based on data recorded by different enterprise software systems.

2.1 Integrating event log and activity data from enterprise systems

Celonis' process mining software helps businesses and other organizations analyze large amounts of event log and activity data[51] from other enterprise systems and therefore provides extensive functionality for **data integration**.[52]

For this purpose, it offers a range of pre-built "connectors" that facilitate constant real-time data flows from ERP, CRM, HRM and data warehousing systems[53] (e.g. SAP, Oracle, Salesforce and Workday), software for task and workflow management (e.g. Jira, Zendesk, ServiceNow) and software for communication and collaboration (e.g. Microsoft Outlook, Google Gmail), among others.[54] In order to "integrate data across systems, departments and silos",[55] organizations can also manually upload event log files to the Celonis system, pull data from databases or build custom integration mechanisms, which ingest data from any other system.[56]

With the help of "**process data models**", Celonis transforms the ingested data into time-stamped records of activities in operational processes.[57] As the next sections show, these records can contain comprehensive personal data about work activities and the tasks carried out by employees.

2.2 Documenting, standardizing, optimizing and monitoring processes

Based on the data ingested from other systems, Celonis' process mining software creates a visual representation of the identified operational processes, including all occurring variants, which are put in relation to KPI metrics such as time, cost, productivity and customer satisfaction.[58] The system promises to help organizations discover and eliminate undesired, inefficient and costly process variants and work activities.[59] Celonis explains that their system can help **standardize, streamline and optimize processes** and align them toward strategic goals, resulting in "acceleration and productivity gains". After the initial implementation, the system can be used to continuously measure and **monitor** "process performance toward KPIs and business outcomes" based on ongoing access to real-time event and activity data.[60] It also provides specific functionality to **document** operational processes[61] and extract "business knowledge" from process data.[62]

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[51] See section 1.1
[52] https://docs.celonis.com/en/data-integration.html [16.5.2023]
[53] See section 1.1
[54] https://www.celonis.com/ems/360-data/, https://docs.celonis.com/en/data-integration.html, https://docs.celonis.com/en/data-connections.html [16.5.2023]
[55] https://www.celonis.com/ems/360-data/ [16.5.2023]
[56] https://docs.celonis.com/en/data-input.html, https://docs.celonis.com/en/event-logs--file-upload-.html, https://docs.celonis.com/en/database--jdbc--connection.html, https://docs.celonis.com/en/extractor-builder-451942.html, https://docs.celonis.com/en/data-push-api.html [16.5.2023]
[57] https://docs.celonis.com/en/process-data-models.html, https://docs.celonis.com/en/event-logs--file-upload-.html [16.5.2023]
[58] https://www.celonis.com/process-mining/how-does-process-mining-work/, https://www.celonis.com/gallery/ [17.5.2023]
[59] https://www.celonis.com/process-mining/how-does-process-mining-work/ [17.5.2023]
[60] Celonis (2020): The Ultimate Guide to Process Mining. A handbook for process excellence, https://assets.ctfassets.net/zmrtlfup12q3/4CUYlOAz0xC07vcbPtznOK/e4a7872feac4d4c713d7ce35cb3604a0/Ultimate_Guide_to_Process_Mining.pdf [17.5.2023]
[61] https://docs.celonis.com/en/process-repository.html [17.5.2023]
[62] https://docs.celonis.com/en/knowledge-model.html [17.5.2023]

2.3 Example – insurance claim handling

A product demonstration video provided by Celonis describes the use of the platform at a vehicle insurance firm.[63] In this example, the system analyzes data on about 143,000 insurance claims with a total payout amount of about $300 million and an average processing time of 32 days. Figure 1 shows Celonis' visual representations of how claims filed by customers are handled at the firm. As figure 1 (center) illustrates, the process includes **steps and work activities** such as creating the claim file, verifying insurance coverage, approving the repair and booking the invoice from the auto repair shop. A claim, which Celonis generically refers to as a "case", can take different paths from the start to the end of the process, each of which may involve different steps. While the simple sequence shown in figure 1 (center) represents the most frictionless and common variant of the process, figure 1 (right) shows another variant that involves additional steps such as handling an evaluation report or updating claim information. In this example, the system discovered 64 **process variants**, which are visualized in the messy graph in figure 1 (left).

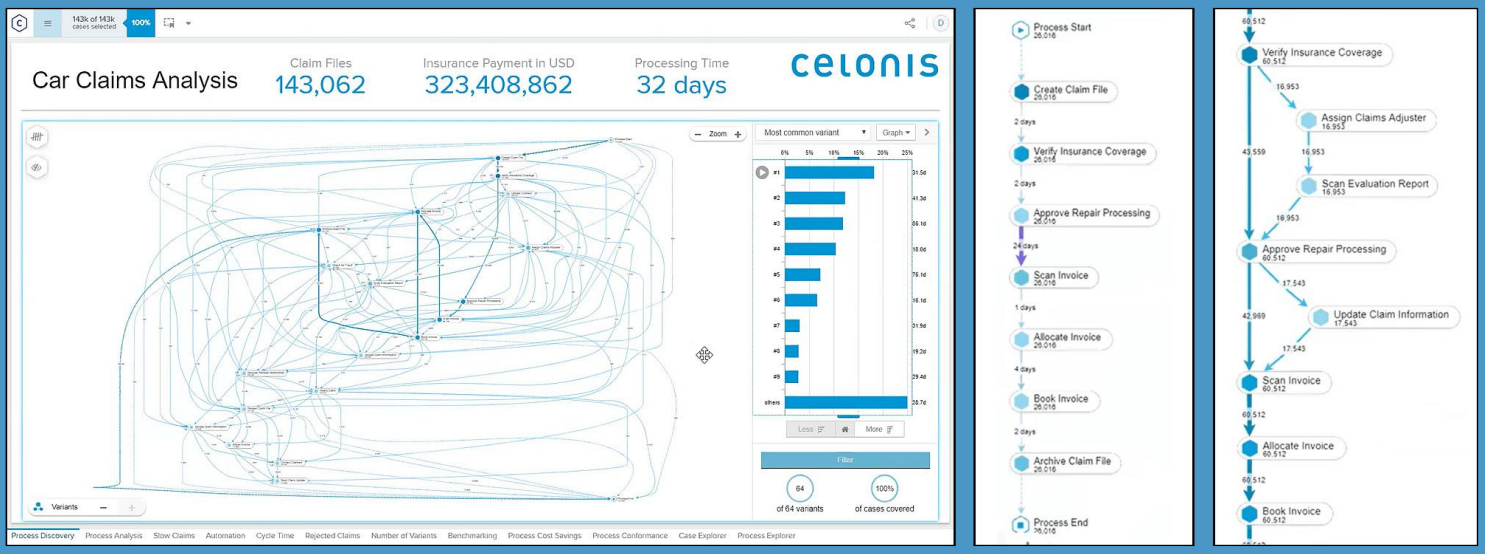

Figure 1: Process analytics for insurance claim handling (Celonis)[64]

The process graphs display numbers for each transition from one step in the process the next, including the number of cases moving through a transition and the average time elapsed between two steps. In this example, 43,559 cases moved directly from the step "verify insurance coverage" to the step "approve repair processing". 16,953 cases took a different path involving two additional steps (figure 1, right). The transition from the work step "verify insurance coverage" to the step "approve repair processing" took two days on average (figure 1, center).

Filtering and benchmarking. The displayed process variants and steps can be filtered by time period, claim payout amount, branch office and other criteria, for example, according to whether a claim was filed by the customer via letter, email or phone. As figure 2 (left) shows, the processes and metrics for branch offices can be compared to each other, for example, in terms of the number of claims handled, the number of rejected claims, the average

[63] https://www.youtube.com/watch?v=p0tKTzesc4g [18.4.2023]

[64] Figures © Celonis. The figures serve as basis for the discussion of the corporate practices examined in this study. Source: Celonis Process Mining - Insurance Industry: Claims Handling, Celonis YouTube channel, 25.2.2019, min 2:52, 4:07, 2:16, https://www.youtube.com/watch?v=p0tKTzesc4g [18.4.2023]

processing time for a claim and the share of claims that are handled at a speed determined to be too "slow".[65] As such, Celonis makes it possible to compare process information between different groups of workers, which it refers to as "benchmarking".[66]

2.4 Detecting process violations and "undesired" activities with "AI"

Additionally, the system assesses the "**conformance**" of a process and uncovers process "violations"[67] by automatically comparing the activities actually occurring in the process with a reference process model.

Figure 2 (center) shows that 60,500 insurance claim cases in this example were considered "conforming cases" while 20,600 cases were found to be "violating cases", the latter of which increased the number of work steps per case from 7.9 to 9.4 on average. In total, Celonis detected 15 types of process "violations", which can then be further investigated in order to eliminate "undesired activities" and streamline the process.

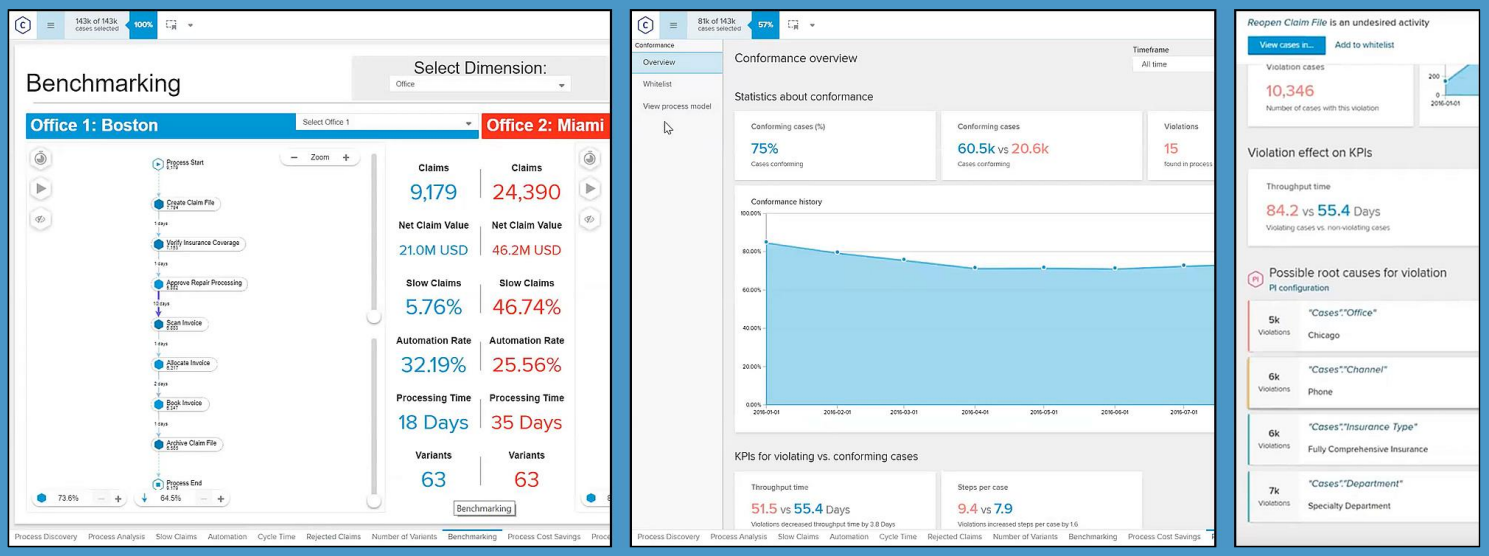

Figure 2: Process analytics for insurance claim handling (Celonis)[68]

Figure 2 (right) shows that the system has identified the step "reopen claim file" as an undesired activity, which affects about 10,000 cases and leads to longer claim processing times. The automated "**root cause analysis**" promises to detect possible reasons for why violations and undesired activities occur, sorted by "correlation strength".[69] The analysis in this example suggests that the problem might be related to a certain department, a particular office, a certain type of insurance contract or to claims filed via phone. Once again, these possible root causes can be further

[65] https://www.youtube.com/watch?v=p0tKTzesc4g [18.4.2023]
[66] https://docs.celonis.com/en/embedded-views.html [31.5.2023]
[67] https://docs.celonis.com/en/conformance-checker.html [31.5.2023]
[68] Figures © Celonis. The figures serve as basis for the discussion of the corporate practices examined in this study. Source: Celonis Process Mining - Insurance Industry: Claims Handling, Celonis YouTube channel, 25.2.2019, min 8:08, 9:00, 10:37, https://www.youtube.com/watch?v=p0tKTzesc4g [18.4.2023]
[69] Ibid.

investigated by drilling down into the analysis of, for example, the cases processed by a particular department or office. Celonis refers to this analysis functionality as "process intelligence" and "process AI".[70]

Process steps and work activities. The steps analyzed in Celonis' process mining system can refer either to activities and tasks carried out by employees or to activities performed by software applications,[71] for example, to an automated update of a database record or an email automatically sent based on certain conditions.[72] Depending on the ingested data, the steps in the process model can represent everything from higher-level procedures to granular work activities and tasks.

2.5 Example – warehouse management

Another example presented on the Celonis website illustrates how the system can be used to analyze and optimize work performed at a warehouse.[73] The graph in figure 3 (left) shows a fine-grained process that consists of "picking" warehouse items, moving, packing and labeling them and then "loading" them for shipping. The steps included make it possible to analyze work activities down to **granular tasks, their durations and outcomes**. The "picking" activity, for example, is divided into the steps "start picking" and "completed picking", which allows the duration of the picking task to be analyzed. Other process steps include "start packing", "completed packing", "start put on conveyer", "completed put on conveyer", "start loading" and "completed loading".

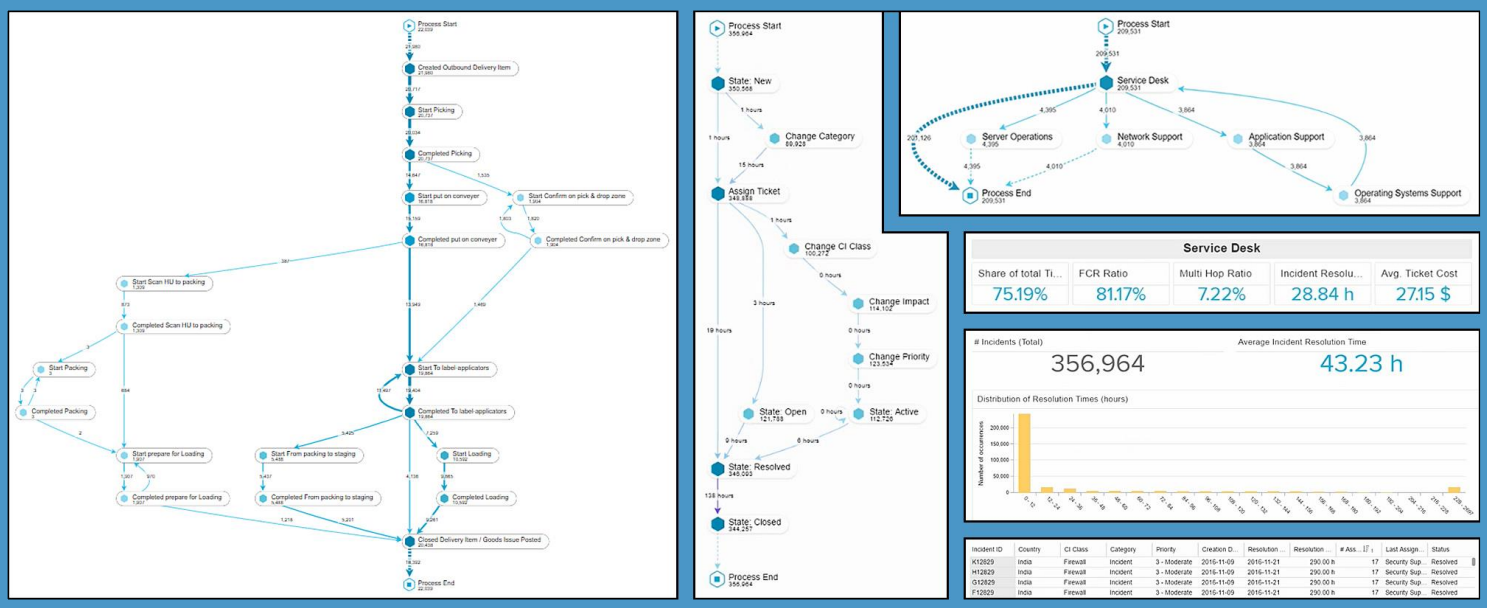

Figure 3: Process analytics for warehouse logistics (McCoy/Celonis) and IT service tasks (Celonis)[74]

[70] https://docs.celonis.com/en/process-ai.html [31.5.2023]

[71] https://docs.celonis.com/en/data-explorer.html [31.5.2023]

[72] See also section 6.2.

[73] McCoy & Partners Intelligent Warehouse Management, Celonis "Partner Execution App": https://www.celonis.com/ems/ems-store/intelligent-warehouse-management/ [8.7.2023]

[74] Figures © McCoy/Celonis. The figures serve as basis for the discussion of the corporate practices examined in this study. Sources: McCoy & Partners Intelligent Warehouse Management, Celonis "Partner Execution App", https://www.celonis.com/ems/ems-store/intelligent-warehouse-management/ [8.7.2023]; Celonis Process Mining for ServiceNow, Celonis YouTube channel, 18.9.2017, min 7:49, 1:53, 5:58, 8:47, https://www.youtube.com/watch?v=ZscU9pIyEVM [19.4.2023]

The analysis in this example, which is based on data from SAP's "Extended Warehouse Management" system, promises to provide "total control" of "outbound logistics processes" and to help discover "inefficiencies and areas for improvement".[75]

2.6 Example – IT service management

Celonis can also be used to analyze and optimize task management at an IT service helpdesk, according to a product demonstration video provided by the company.[76] According to Celonis, its technology helps to "optimize" the service management process, analyze it "precisely from start to end", improve its "efficiency" and "shorten" the "time to resolution".[77]

The process graph in figure 3 (center) represents every step of how incoming service requests turn into "tickets" that need to be addressed by workers. Initially, an incoming request is in the state "new". Subsequently, it is assigned to a worker as a **task**, who either marks it as "resolved" or as "open" when further work is required. The graph shows how much time elapses between each process step, based on an analysis of about 350,000 service desk requests. It also visualizes some less streamlined variants of the process that require additional work steps. Figure 3 (top right) shows another representation of the process that focuses on different departments with particular duties such as "server operations", "network support", "application support" and "operating systems support".

In addition, the system displays **metrics** about average resolution times, the share of requests that were immediately resolved without any further work ("first contact resolution", FCR),[78] and the **average cost** of a ticket, which amounts to $27.15 in this example (figure 3, right).

As shown in figure 3 (bottom right), the system also provides access to the **full list of service requests**. While this list does not contain information about the worker who handled a request, each record includes a unique "Incident ID", which may make it possible to identify the worker who handled the request with the help of other information.

2.7 The role of personal data

The example applications described in the previous sections, from insurance claim handling to warehouse operations to task management, do not display personal data about individual workers and their activities as part of the analysis results, according to the available materials provided by Celonis.

The user interface for the "root cause analysis" in figure 2 (right) displays a warning indicating that the analysis may expose personal information ("PI") and offers to customize the attributes from the data model that are utilized in the analysis. By default, however, all available attributes are used in the analysis.[79] Which attributes are available depends on the ingested event log and activity data.

Generally, it is possible to use Celonis' process mining software strictly based on data that does not contain any personal data about employees. Celonis emphasizes that the "customer decides which types of event data from

[75] Ibid.
[76] https://www.youtube.com/watch?v=ZscU9pIyEVM [19.4.2023]
[77] min 0:19, https://www.youtube.com/watch?v=ZscU9pIyEVM [19.4.2023]
[78] See e.g. https://en.wikipedia.org/wiki/First_Call_Resolution
[79] https://docs.celonis.com/en/conformance-checker.html [31.5.2023]

which source systems are extracted and uploaded".[80] The software documentation, however, suggests at several points that ingesting and analyzing activity records that contain **extensive personal data about workers** is a very common practice. When Celonis explains, for example, how to ingest "raw data" from a task management system, it proposes including information about which person created a service request and which person closed the ticket.[81] The documentation about the "data explorer" functionality, which makes it possible to view raw event log and activity data ingested into the Celonis system, prominently displays a list of about 620,000 activity records that include pseudonymous user identifiers.[82] Celonis "encourages" clients to include the "user ID" that refers to each employee when using the "process simulation" module (see section 3.2). While identifying workers based on **pseudonymous identifiers** may require additional information, these activity records can be clearly considered "personal data" under the GDPR.[83] As detailed in section 4, the Celonis platform not only makes it possible to analyze extensive amounts of personal data on workers and work activities, but also routinely displays **individual-level information** about employees in different types of reports and analysis results, including performance ratings and rankings. Section 6 shows how the platform can also use personal data to automate workflows across enterprise software systems, which may include **acting on employees** at the individual level and **making decisions** about them.

Privacy and data protection. Celonis promises that it aims to build software that "supports" its customers in "complying with internal privacy policies and applicable data protection legislation" and claims it has "designed" its software according to the GDPR concept of "data protection by design and default".[84] The company states its system "supports the need to collect personal data only for a specific, explicit and legitimate purpose" and "helps" customers to "process personal data lawfully, fairly and in a transparent manner".[85] It disclaims, however, any responsibility by emphasizing that its software is "highly configurable" and customers would be "in full control of any Personal Data uploaded". To minimize personal data processing, customers should "only select data categories that are required for the specific purpose" and apply "anonymization and pseudonymization filters".[86]

Nevertheless, the system potentially processes extensive **personal data on workers and work activities** in order to analyze and optimize processes, irrespective of whether the user interface displays personal data as a result of the analyses or not.

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[80] Celonis (2022): Whitepaper Data Privacy. October 2022, https://assets.ctfassets.net/zmrtlfup12q3/3AKV2pDI41W6OMSjwWnYOX/990fc5779f7ffa18002ca7e546cb9e55/WHITEPAPER_Celonis_Privacy_Oct2022_final.pdf [31.5.2023]

[81] Attributes "Created_by" and "Closed_by": https://docs.celonis.com/en/servicenow-example.html [31.5.2023]

[82] "USER ID" column, https://docs.celonis.com/en/data-explorer.html [31.5.2023]

[83] Pseudonymization involves the replacement of names and other identifying attributes with pseudonyms, for example by combinations of letters and digits. The EU General Data Protection Regulation defines it as the "processing of personal data in such a manner that the personal data can no longer be attributed to a specific data subject without the use of additional information". When additional information, for example, how names relate to pseudonyms, is known, pseudonymity can be easily reversed. In some companies, it may be common knowledge who a particular employee ID refers to. In other cases, information linked to the pseudonym, for example, information on work activities, time and location, may reveal the identity of the employee. In addition, pseudonyms are perfectly suitable for singling out people or acting on them in digital environments. For more details see, e.g., Christl and Spiekermann (2016, p. 22), Borgesius (2016).

[84] https://assets.ctfassets.net/zmrtlfup12q3/3AKV2pDI41W6OMSjwWnYOX/990fc5779f7ffa18002ca7e546cb9e55/WHITEPAPER_Celonis_Privacy_Oct2022_final.pdf [31.5.2023]

[85] https://www.celonis.com/trust-center/privacy/ [31.5.2023]

[86] https://assets.ctfassets.net/zmrtlfup12q3/3AKV2pDI41W6OMSjwWnYOX/990fc5779f7ffa18002ca7e546cb9e55/WHITEPAPER_Celonis_Privacy_Oct2022_final.pdf [31.5.2023]

3. From process analysis to algorithmic management

Celonis is considered a pioneer in "process mining".[87] In 2020, it began to promote its software as an "**execution management system**" (EMS),[88] putting the focus more on changing and managing operational processes rather than merely analyzing them. The company even refers to its software as an "operating system" for enterprises[89] that not only helps them standardize, streamline and optimize processes but also "orchestrate" processes.[90] The term "orchestration" has become popular in business literature and marketing to describe the management and coordination of operational processes across different software, automation systems and workers (see e.g. Ruecker, 2021).

The next sections describe software modules and mechanisms that go beyond the analysis of processes.

3.1 Managing, automating and monitoring process changes

Celonis provides a software module labeled "**transformation center**", which it refers to as a "navigation system" that should help organizations "steer" their "transformation journey". It makes it possible to determine goals, objectives and targets for certain KPI metrics in a process and then tracks progress towards these KPI targets over time.[91]

Targets for KPI metrics. Figure 4 (left) shows how the transformation center displays numbers and charts about a company's "on-time delivery rate" over the course of several months. Swinging between 26% and 74%, it should reach 99% in three months, according to a defined target that is referred to as a "milestone". Figure 4 (top right) shows how KPI target values and corresponding deadlines can be defined.

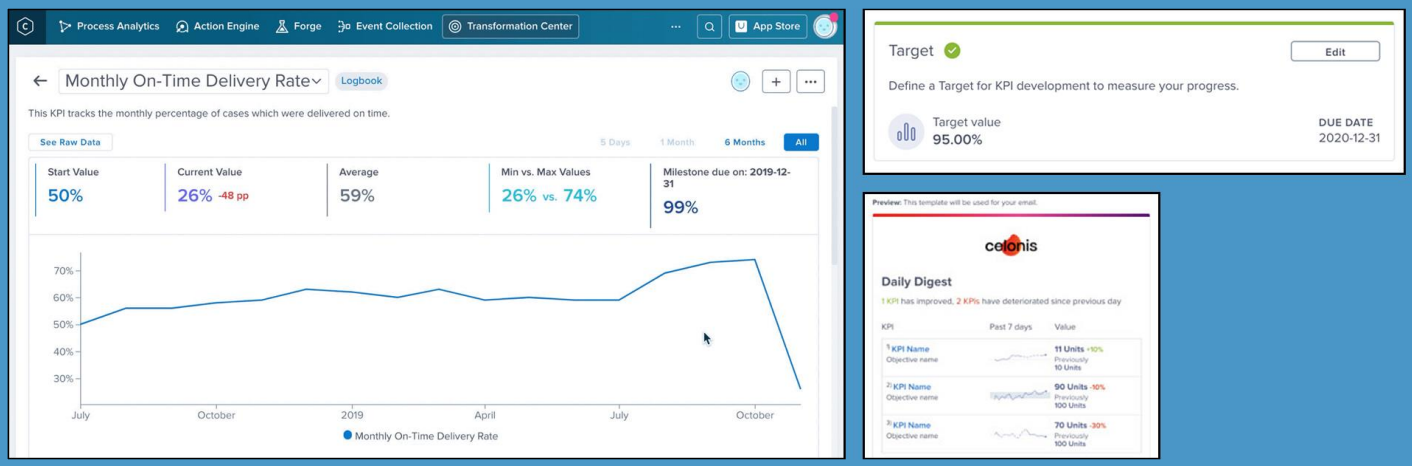

Figure 4: Determining and tracking KPI targets (Celonis)[92]

[87] Gartner (2023): Magic Quadrant for Process Mining Tools. Gartner, 20.3.2023
[88] https://www.celonis.com/company/ [26.6.2023]
[89] https://www.celonis.com/blog/what-is-execution-management/ [26.6.2023]
[90] https://www.celonis.com/blog/more-to-process-mining-than-hyperautomation/ [26.6.2023]
[91] https://docs.celonis.com/en/transformation-center.html [26.6.2023]
[92] Figures © Celonis. The figures serve as basis for the discussion of the corporate practices examined in this study. Sources: https://docs.celonis.com/en/assign-owners.html, https://docs.celonis.com/en/kpi-configuration.html, https://www.celopeers.com/s/question/0D50700000XlNIxCAN/does-transformation-center-allow-exporting-reports [26.6.2023]

Almost any type of KPI metric[93] related to measures such as time, cost, productivity and efficiency can become part of a "process improvement initiative",[94] which is always "owned" by particular employees, such as managers or analysts,[95] who are responsible for reaching the defined objectives and targets. The system can also assign "tasks" related to improvement initiatives to employees[96] and send them email reports that contain information such as "1 KPI has improved, 2 KPIs have deteriorated since previous day", as shown in figure 4 (bottom right).

As this Celonis module aims to maintain or change operational processes through defined objectives, tracking them over time, assigning tasks to managers and sending them recommendations for action, it represents a form of **management automation**. It can also be considered a form of performance monitoring and control mechanism for managers. As the module helps employers to restructure and streamline work, its use potentially affects employees.

3.2 Simulating and forecasting the impact of process changes

Celonis also offers a software module for "**process simulation**" that promises to predict the impact of potential changes to a process on a company's operations. For this purpose, it creates a "digital twin" from the actual process data, which can then be used to create simulation "scenarios".[97]

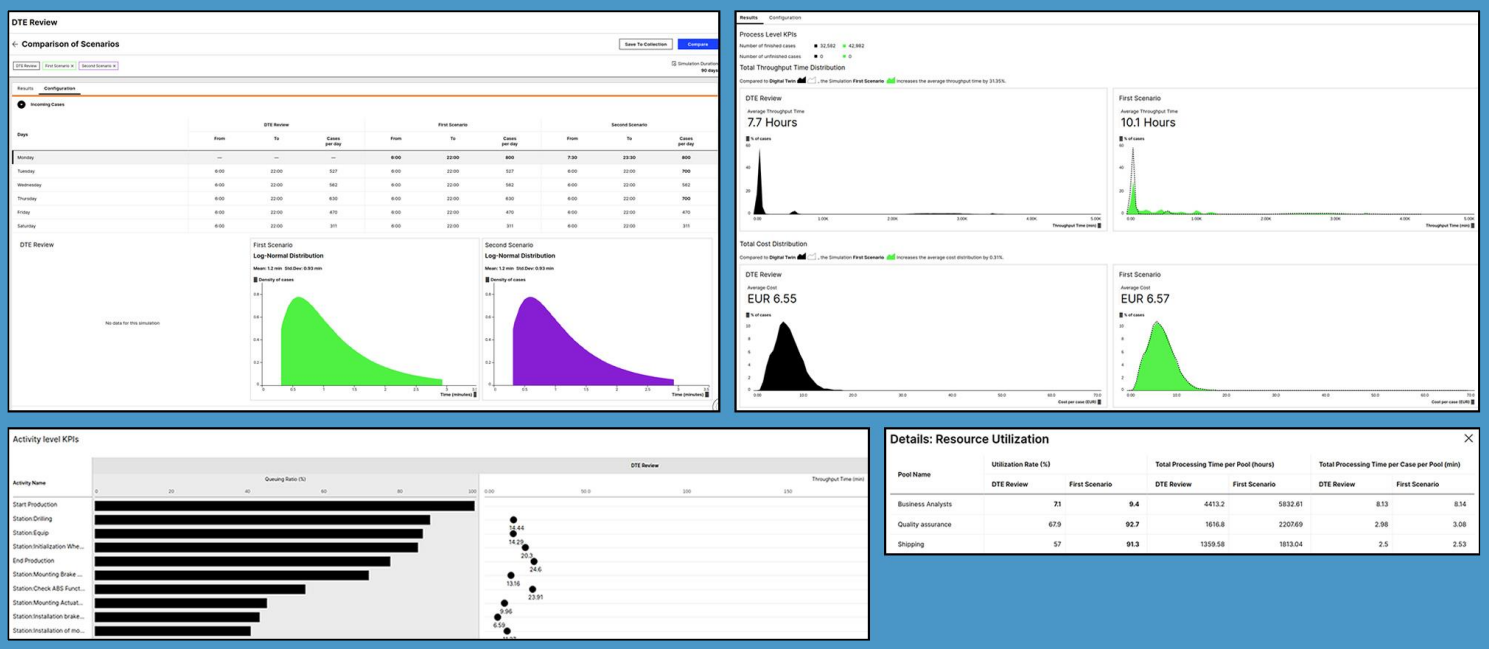

Figure 5: Simulating and forecasting the impact of process changes (Celonis)[98]

Figure 5 shows example screens from the Celonis documentation that appear to address a quality control process in manufacturing and which includes work steps such as drilling, mounting brakes and checking ABS functionality.

[93] https://docs.celonis.com/en/kpi-configuration.html [26.6.2023]
[94] https://docs.celonis.com/en/define-objectives.html [26.6.2023]
[95] https://docs.celonis.com/en/assign-owners.html [26.6.2023]
[96] https://docs.celonis.com/en/add-and-assign-tasks.html [26.6.2023]
[97] https://docs.celonis.com/en/process-simulation.html [26.6.2023]
[98] Figures © Celonis. The figures serve as basis for the discussion of the corporate practices examined in this study. Sources: https://docs.celonis.com/en/viewing-and-comparing-results.html, https://docs.celonis.com/en/process-level-kpis.html, https://docs.celonis.com/en/results.html, https://docs.celonis.com/en/pool-level-kpis.html [26.6.2023]

The simulation module created a "digital twin" of the process, which is referred to as "DTE" (digital twin extraction[99]) and includes information about how many manufacturing units (or "cases") go through the process each day of a week, as shown in figure 5 (top left). While the production line is currently processing 527 units on a Tuesday, the system simulates a scenario that increases the number of units going through the process on a Tuesday to 700.

While figure 5 (top right) shows how a simulated scenario would change the "average throughput time" and the "average cost" per unit,[100] figure 5 (bottom right) indicates how the scenario would change the amount of time different teams spend on the process and how it would change their workload.[101] In this example, the workload for the "quality assurance" team would increase from 67.9% to 92.7% in the simulated scenario. The workload for the "shipping" team would increase from 57% to 91.3%. Figure 5 (bottom left) displays information about the "average throughput time" per process step and about how long manufacturing units are waiting to proceed to the next process step.[102]

As the simulation module can help employers to **streamline work activities and maximize workload**, its use can have a massive impact on employees. Creating "digital twins" from actual process data relies on extensive data processing. While the inclusion of identifiable data about employees in the source data is optional, Celonis "encourages" clients to include optional fields such as the "user ID", because they "improve the extraction results". Including the user ID helps with "resource clustering, processing, and […] time estimations".[103] Predicting the workload for different groups of employees requires the inclusion of their user IDs in the source data.[104] This suggests that the simulation module will usually process extensive personal data on employees.

3.3 Managing and automating processes, task assignment and "apps"

While Celonis' "execution management system" (EMS), subsequently referred to in this case study as the "Celonis system", has "process mining technology as its base",[105] it includes additional functionality for managing and automating operational processes, work activities and task assignment.

The "Studio" software module, for example, allows employers and third-party vendors to build applications that "combine analytics and execution capabilities" in order to "tackle specific business challenges".[106] These applications can contain four components:

- **knowledge models**, which contain process data models (see section 2.1) and definitions of variables, KPI metrics, filters, benchmarks and other "business knowledge entities"[107]
- **analysis functionality**, which includes process mining technology, as detailed in section 2
- **user interface functionality**, which displays reports, dashboards, KPI metrics, charts, controls and other elements based on process mining data or information from other enterprise systems[108]

[99] https://docs.celonis.com/en/digital-twin-extraction.html [26.6.2023]
[100] https://docs.celonis.com/en/process-level-kpis.html [26.6.2023]
[101] https://docs.celonis.com/en/pool-level-kpis.html, https://docs.celonis.com/en/pool-details.html [26.6.2023]
[102] https://docs.celonis.com/en/activity-level-kpis.html [26.6.2023]
[103] https://docs.celonis.com/en/initial-configuration.html [26.6.2023]
[104] https://docs.celonis.com/en/resources.html [26.6.2023]
[105] https://docs.celonis.com/en/execution-management-system--ems--overview.html [26.6.2023]
[106] https://www.celonis.com/ems/celonis-studio/ [26.6.2023]
[107] https://docs.celonis.com/en/knowledge-model.html [26.6.2023]
[108] https://docs.celonis.com/en/views.html [26.6.2023]

- **automation functionality**, which involves semi-automated or fully automated activities across Celonis and other enterprise systems including mechanisms for alerts and task assignment[109]

These applications, which Celonis refers to as **execution applications**, help organizations monitor, analyze, optimize, automate and manage particular operational processes and can "both automate routine decisions and activate the right people to take hands-on actions".[110] Celonis itself offers about 180 pre-built execution applications.[111] Like many cloud-based enterprise software systems, it has turned into a **platform** that can be expanded through applications created by third-party vendors, who offer more than 200 execution applications via Celonis' **app marketplace**.[112] This includes, for example, a "production control tower" application (see section 4.3) and applications for warehouse management (see section 2.5), IT services management (see sections 2.6 and 4.1) or conversation monitoring in call centers (see section 4.2). Employers can build their own applications with the help of the "Studio" software module, which Celonis refers to as a "low-code development environment"[113] that allows managers, business analysts and other non-programmers to build applications by combining components and data flows without much coding.[114]

Automating workflows, data flows and task assignment. In addition, Celonis offers a wide range of functionality for process and workflow automation, which utilizes process mining data and other information to automatically initiate activities across Celonis and other enterprise systems such as SAP, Oracle, Salesforce and Microsoft 365. This includes the automated assignment of tasks to employees and is further examined in section 6.

4. Singling out workers and ranking them by performance

Celonis' process mining technology can be used to analyze, optimize and streamline processes and work activities without displaying personal data about employees in reports or analysis results. This section documents and examines example applications that expose and utilize data at the individual level, from singling out workers for purposes that may be considered legitimate to granular monitoring of behaviors and work performance. Most of the Celonis-based applications examined in this section are "execution applications" provided by third-party vendors via the Celonis app marketplace (see section 3.3).

4.1 Analyzing processes and work performance at the individual level

Section 2.6 describes how Celonis can be used to analyze and optimize service management at an IT helpdesk, a process that involves turning incoming service requests into "tickets" that represent tasks to be handled by employees. While this application does not display personal data about workers and their activities as part of the analysis results, another example application presented on the Celonis website, which also addresses IT service management,[115] illustrates how the system can indeed display worker data at the individual level.

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[109] https://docs.celonis.com/en/skills-and-automation.html [26.6.2023]
[110] https://docs.celonis.com/en/business-apps.html [26.6.2023]
[111] https://www.celonis.com/ems/marketplace/ [26.6.2023]
[112] Ibid.
[113] For "low-code" application development see e.g. Gartner (2022): Magic Quadrant for Enterprise Low-Code Application Platforms. Gartner, 31.12.2022
[114] https://www.celonis.com/ems/celonis-studio/, https://docs.celonis.com/en/new---studio-visual-editing-experience.html [26.6.2023]
[115] Navcara - Incident Management: Priority Driven and Response Time, Celonis "Partner Execution App", https://www.celonis.com/ems/ems-store/incident-management-priority-driven-and-response-time/ [8.7.2023]

Analyzing processes, work activities and metrics at the individual level. Figure 6 (right) shows how Celonis' benchmarking functionality can be used to compare processes, work steps and metrics for two distinct workers. In this example, service tickets handled by one employee named Charlie Witherspoon are compared to the tickets handled by another employee named Luke Wilson. For both workers, a process graph and the average time they spent completing their tasks are displayed, the latter of which represents a performance ranking. The menu item in the Celonis user interface is labeled "**Employee Productivity**". While this analysis includes only a very small number of tasks, which appears to be due to the fact that the screen shows demonstration data, this example indicates that the Celonis system can compare processes, work steps and metrics not only between different branch offices, departments and other groups of workers, as detailed in section 2.3, but also between individuals.

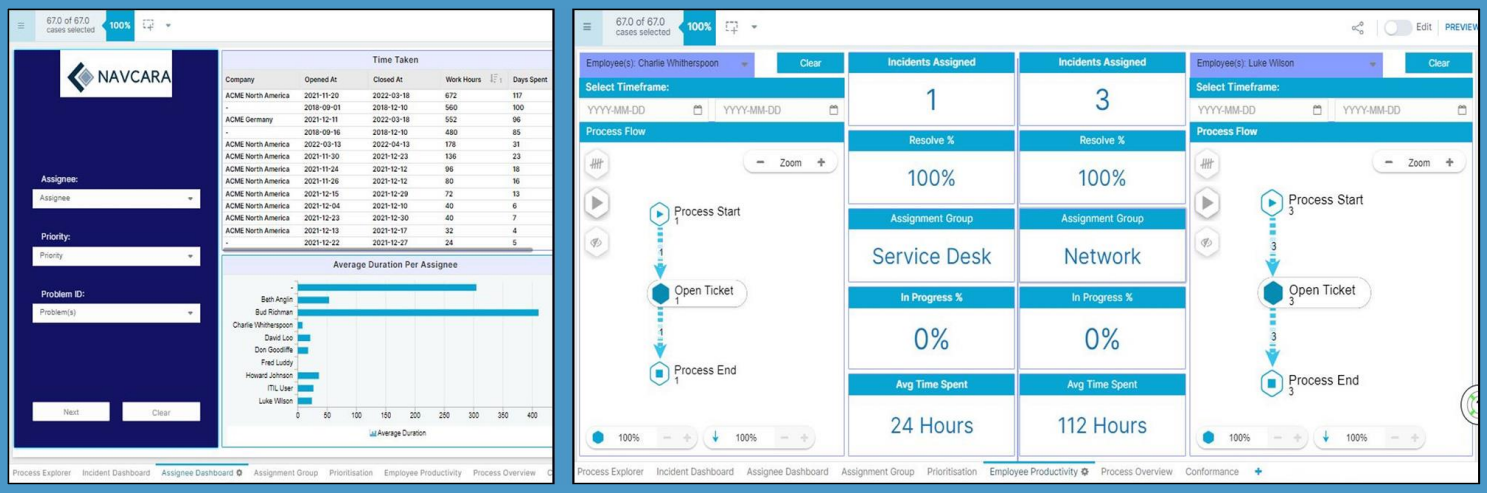

Figure 6: Process analytics and performance monitoring for IT service tasks (Navcara/Celonis)[116]

As shown in figure 6 (left), the "assignee dashboard" in this example contains a chart that displays individual-level **performance ratings** for a larger group of workers, who are referred to as "assignees", showing the average time each worker spent on resolving service tickets. The full screenshot on the Celonis website shows another chart that displays the percentage of service tickets each worker has successfully resolved.[117] As such, the system displays individual-level performance ratings for both the outcomes of the assigned tasks and the time required to complete them. In addition, the system generally provides an option to filter information by "assignee", which appears to enable access to further details about the work conducted by individual workers (figure 6, left).

The example application provides additional reports that display information on opened and completed tasks over time, service level compliance, the current share of "overdue" tickets and other group metrics.[118] According to its description, the application aims to help employers identify "execution gaps" in the "incident management" process,

[116] Figures © Navcara/Celonis. The figures serve as basis for the discussion of the corporate practices examined in this study. Source: Navcara - Incident Management: Priority Driven and Response Time, Celonis "Partner Execution App", https://www.celonis.com/ems/ems-store/incident-management-priority-driven-and-response-time/ [8.7.2023]

[117] https://www.celonis.com/ems/ems-store/incident-management-priority-driven-and-response-time/ [8.7.2023]

[118] Ibid.

increase customer satisfaction, monitor performance and employee productivity, decrease response times and minimize cost.[119]

4.2 Granular behavior and performance control in the call center

Another example presented on the Celonis website[120] shows how the company's process mining technology can be utilized for granular behavior and performance control in the call center, based on the analysis of what workers say in conversations, the "sentiment" in their calls and the extent they are following a specified script. Today's call center software provides functionality to assess work activities down to the second and even to fully monitor and automatically rate communication content. Call center agents must conform to rigid scripts and are pushed to the maximum level of work they can manage (Christl, 2023).

Turning conversations into process transactions. Figure 7 shows screenshots from a Celonis-based "conversation mining app" provided by the call center technology vendor LivePerson.[121] As indicated in figure 7 (left), the system analyzes data on about 194,000 calls handled by workers in a customer service center of an airline.

Figure 7: Conversation, behavior and performance monitoring of call center workers (LivePerson/Celonis)[122]

The process graph visualizes every step in a call: starting a call, greeting and identifying the customer, determining the reason for the call, gathering flight information, resolving the call. It appears that workers are expected to carry out two additional tasks before finishing a call. They should sell a credit card to the customer and ask them to answer a survey. The process graph displays metrics about the number of calls that passed from one step to the next. It can be filtered by agent, which turns the aggregate process graph into a detailed analysis of the behavior of individual workers. The automated detection of conversation steps such as "greeting", "determine reason for call" and "offer

[119] Ibid.

[120] LivePerson - Conversation Mining App, Celonis "Partner Execution App": https://www.celonis.com/ems/ems-store/conversation-mining-app/ [8.7.2023]

[121] https://ir.liveperson.com/ [6.6.2023]

[122] Figures © LivePerson/Celonis. The figures serve as basis for the discussion of the corporate practices examined in this study. Source: LivePerson - Conversation Mining App, Celonis "Partner Execution App", https://www.celonis.com/ems/ems-store/conversation-mining-app/ [8.7.2023]

credit card" rely on recording and analyzing the workers' speech, which is likely based on LivePerson's "conversational intelligence" technology.[123] Subsequently, the Celonis application translates the conversation data into process data, and as such, behavioral and communication data into transactional data.

Assessing "agent quality" and other performance metrics. Figure 7 (left) also shows a table on "agent metrics", which lists individual-level performance metrics for a number of named workers. This includes the number of calls handled by an agent, the average duration of their calls ("average handle time", AHT[124]), the share of customer calls resolved within the initial conversation ("first call resolution", FCR), a metric that assesses the "sentiment" in their conversations and a score that claims to assess the agent's overall "quality". Performance metrics that are considered acceptable are colored green, which turns into yellow and red for metrics that are considered inadequate. One worker named "Allison", for example, handled 21,381 customer calls with an average duration of 14.99 minutes, which is one minute more than the average call duration across all workers. A share of 63.9% of her calls were resolved within the initial customer conversation, which is considered too low and thus colored yellow. In total, this agent is assessed with a quality score of 66.1%, which is deemed insufficient and thus colored red.

Sales performance and behavioral compliance. As workers are expected to offer and sell a credit card to customers, the system provides further analyses for this process step. Once again, the screenshot in figure 7 (right) shows individual-level performance metrics for a number of named workers, including the number of calls they handle per hour and their "card acceptance rate", i.e. the share of an agent's calls that resulted in customers opening a credit card. One agent named Michael, for example, had a card acceptance rate of 6.1%, which is less than the average acceptance rate of 9.7% across all workers.

Figure 7 (right) shows a table that addresses agent behaviors that are possible reasons for low acceptance rates, and thus considered inadequate. For example, when agents were observed to offer the credit card before resolving the customer request, the acceptance rate was only 0.8%. The process graph in figure 7 (left) indicates that workers are expected to offer the credit card before finishing the call, but after resolving the customer request. The system also quantifies the financial impact on the company. Offering the credit card before resolving the customer request, which occurred in 7,104 out of 104,000 calls, is estimated to cost the company $1.3 million. Similarly, acceptance rates and costs are calculated for calls where agents generally did not "follow [the] protocol" or "failed to offer" the credit card at all.

Taken together, this example application shows how Celonis' process mining technology can turn into a comprehensive behavior and performance monitoring system. According to its description, the application aims to increase "contact center and sales performance", improve customer satisfaction, increase revenue and reduce costs.[125] Using Celonis' "action flows" technology, which is examined in section 6.2, the application can also be used to **automate workflows** "based on what's showing up in customer conversations in near real-time".[126]

[123] https://www.liveperson.com/products/conversational-cloud/ [6.6.2023]
[124] See Christl (2023).
[125] https://www.celonis.com/ems/ems-store/conversation-mining-app/ [8.7.2023]
[126] Ibid.

4.3 Monitoring worker performance by the second in manufacturing

The consulting firm Doculabs presents a "Production Control Tower" application on the Celonis website, which allows manufacturers to "integrate all of their data sources" to "create a real-time, digital representation of how the production process is truly performing" in order to "identify process deviations and prioritize which have the greatest impact on productivity, quality, and cost".[127]

Figure 8 (left) shows a Celonis-based dashboard, which displays data on a manufacturer's "paint line" including a process graph that displays steps such as "begin paint", "hang parts", "hand spray", "paint application", "paint oven" and "off load". The graph displays the number of units that went from one process step to another and the average duration of the transitions between the steps. For example, 787 units went through the step "begin paint" and it took three minutes on average to transition to the step "hang parts". The dashboard also shows charts on the actual daily output in relation to the planned number of units and on "cycle times" from the start to the end of the paint process. In total, the average "cycle time" was 33.8 minutes, as opposed to the planned average cycle time of 30.66 minutes.

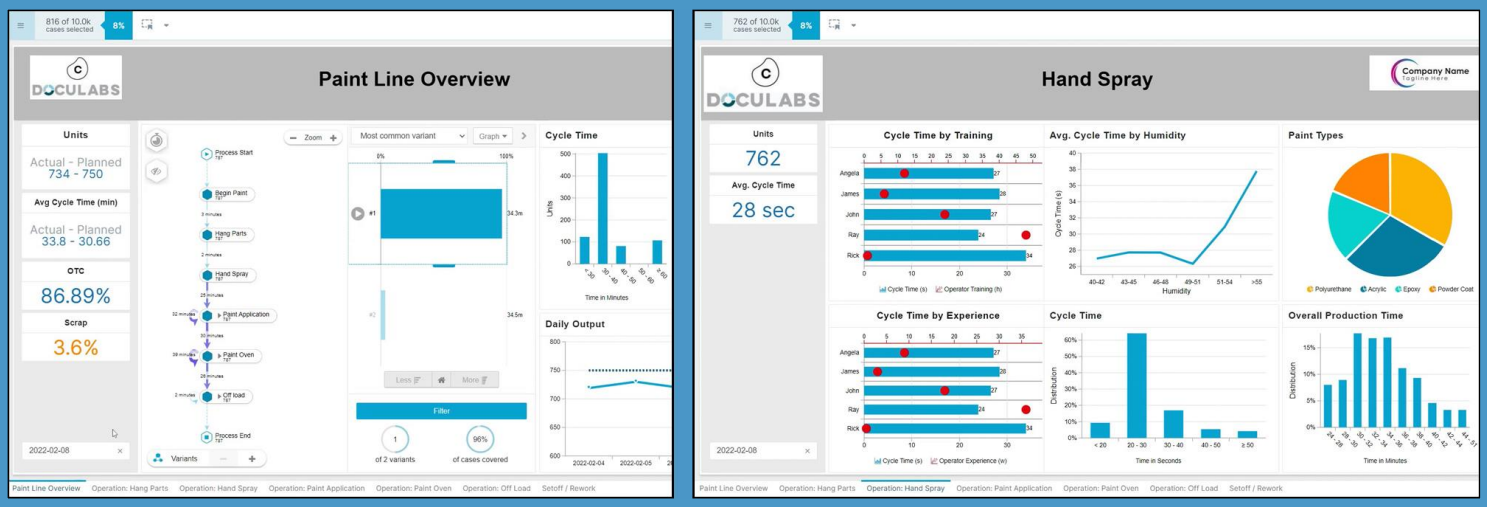

Figure 8: Process analytics and performance monitoring in manufacturing (Doculabs/Celonis)[128]

While the screen shown in figure 8 (left) refers to the paint line, which might be only one production line of a larger manufacturing operation, figure 8 (right) zooms into a single work step in the paint process, which is labeled "hand spray". This step appears to consist of a rather short task with an average duration of 28 seconds. While the other dashboards show aggregate data only, this screen displays the exact time individual workers spent on this task. A person named "Ray", for example, spent only 24 seconds on hand spraying. "Angela" spent on average 27 seconds on the task, which is three seconds more than "Ray". The slowest worker listed is "Rick", who spent 34 seconds on hand spraying. The lists not only show **how many seconds individual workers spent on the task**, but also how many minutes of "training" each worker received and how many weeks of "experience" they have.

[127] Doculabs - Production Control Tower, Celonis "Partner Execution App": https://www.celonis.com/ems/ems-store/production-control-tower/ [7.6.2023]

[128] Figures © Doculabs, Celonis. The figures serve as basis for the discussion of the corporate practices examined in this study. Source: The Production Control Tower Shows How Process Mining Can Improve Manufacturing Processes. Doculabs YouTube channel, 7.4.2022, min 6:04 and 6:53: https://www.youtube.com/watch?v=fAcrVyMyfaQ [7.6.2023]

Experience, training and working speed. An employer could argue that these charts can be useful for studying the impact of training and experience on working speeds and for making decisions about training allocation. While the latter can be a legitimate use, the former certainly does not necessarily require displaying performance ratings at the individual level. To analyze the impact of training and experience, the system could display aggregate statistical correlations between cycle times, the amount of training and experience. In addition, such a coarse quantification of training and experience may miss other relevant factors such as differences between units, working conditions and individual ability.

Assessing working speed by the second at the individual level and comparing it across workers can serve as a form of **performance monitoring and control**. Instead of allocating training to workers who are considered to be too slow, managers and supervisors could use these charts to push workers to work faster or to make decisions about those workers considered to be too slow despite training and experience. As such, these charts pose the risk that they could be used for a different purpose than what is suggested in the user interface. In any case, this example, once again, shows that Celonis' technology can be used for granular performance monitoring.

Remarkably, Doculabs describes its "process mining solution demonstrations" as being "based on anonymized data".[129] In fact, nothing about what is shown in figure 8 (right) is based on anonymized data. On the contrary, the application processes personal data about workers and their activities and also displays it in the user interface.

4.4 Process mining and performance monitoring in creative work

Celonis technology can also be used to assess and optimize creative work that involves the design, production, editing, review and approval of creative assets, from video to web to marketing collateral.

An example application presented on the Celonis website,[130] also provided by the consulting firm Doculabs, analyzes data extracted from Adobe Workfront, a "work management" system that can be integrated with other Adobe software such as Photoshop, Illustrator, InDesign and Premiere.[131] Figure 9 (left) shows how the Celonis application displays a process graph and metrics on creative tasks, projects and their durations. Other screens display analyses about the share of projects finished "on time" and the share of creative tasks that required "rework" activities. All analysis results can be **filtered by employee** and thus can display personal data on workers at the individual level.[132] In this example, the system analyzes about 8,000 creative projects that consist of many different work activities, such as copywriting, proofreading, suggesting edits and uploading files.[133]

Figure 9 (right) shows how many hours a number of named employees spent creating deliverables of the type "video". The voiceover in the product demonstration video on the Celonis website explains that this screen makes clear that "Alexis spent over 12 hours on each video, which is much higher than her peers", who "were able to

[129] Doculabs - Production Control Tower, Celonis "Partner Execution App": https://www.celonis.com/ems/ems-store/production-control-tower/ [7.6.2023]
[130] Doculabs - Adobe Workfront Optimization Solution, Celonis "Partner Execution App": https://www.celonis.com/ems/ems-store/adobe-workfront-optimization-solution [6.6.2023]
[131] https://business.adobe.com/products/workfront/project-management.html, https://business.adobe.com/products/workfront/creative-cloud-integration.html [6.6.2023]
[132] Doculabs - Adobe Workfront Optimization Solution, Celonis "Partner Execution App": https://www.celonis.com/ems/ems-store/adobe-workfront-optimization-solution [6.6.2023]
[133] Ibid.

complete it in much less time", which "may be due to over-assignment or mismatches in skill".[134] While addressing high workloads and skill mismatches can represent a legitimate purpose, this ranking can, of course, also be used for performance control and other decisions about employees.

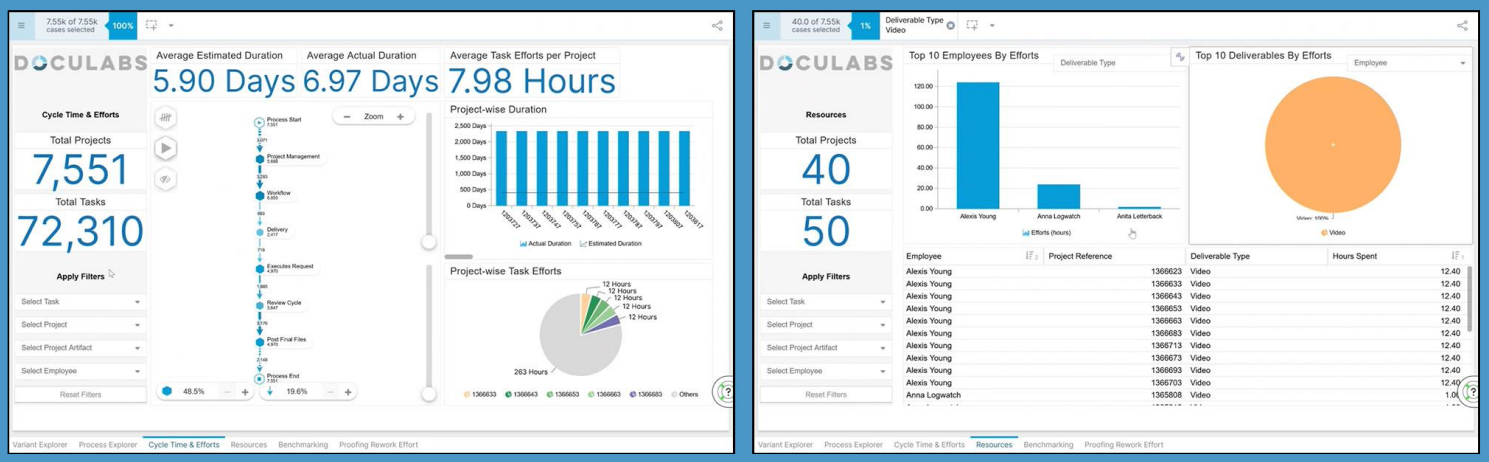

Figure 9: Process mining and performance monitoring in creative work (Doculabs/Celonis)[135]

4.5 Singling out workers in manufacturing quality management

The Celonis website presents another example application[136] provided by MHP, an IT consulting firm owned by the German automobile manufacturer Porsche.[137] Based on data extracted from an SAP complaint management module, it uses Celonis' process mining technology to analyze and optimize how incoming customer complaints lead to the creation of "quality notifications", defect descriptions, root cause descriptions and corresponding "tasks" that need to be handled. Several dashboards and reports show aggregate information about complaints, quality notifications, defective parts, costs and other metrics.[138] But not all information is displayed at an aggregate level.

Figure 10 (top right) shows a part of the user interface that displays the number of tasks assigned to individual employees. The table legend suggests that this information is displayed in order to balance the workload across employees and avoid assigning too many tasks to them, which is a legitimate purpose. The report, however, also singles out employees who work on low numbers of tasks. Figure 10 (bottom right) displays data on individual workers who reported quality notifications that may represent "possible cost drivers" and makes it possible to search for the names of employees. Depending on how this functionality is used in practice, it may or may not represent a

[134] Doculabs - Adobe Workfront Optimization Solution, Celonis "Partner Execution App": https://www.celonis.com/ems/ems-store/adobe-workfront-optimization-solution [6.6.2023]

[135] Figures © Doculabs, Celonis. The figures serve as basis for the discussion of the corporate practices examined in this study. Sources: Doculabs - Adobe Workfront Optimization Solution, Celonis "Partner Execution App". Video stills min 3:13, 3:40, https://www.celonis.com/ems/ems-store/adobe-workfront-optimization-solution/ [6.6.2023]

[136] MHP Complaint Management Process Cockpit, Celonis "Partner Execution Instrument": https://www.celonis.com/ems/ems-store/mhp-complaint-management-process-cockpit/ [6.6.2023]

[137] https://www.mhp.com/en/about-mhp [6.6.2023]

[138] MHP Complaint Management Process Cockpit, Celonis "Partner Execution Instrument": https://www.celonis.com/ems/ems-store/mhp-complaint-management-process-cockpit/ [6.6.2023]

legitimate purpose. In any case, the application clearly analyzes personal data on work activities and **displays personal data about workers** in the user interface.

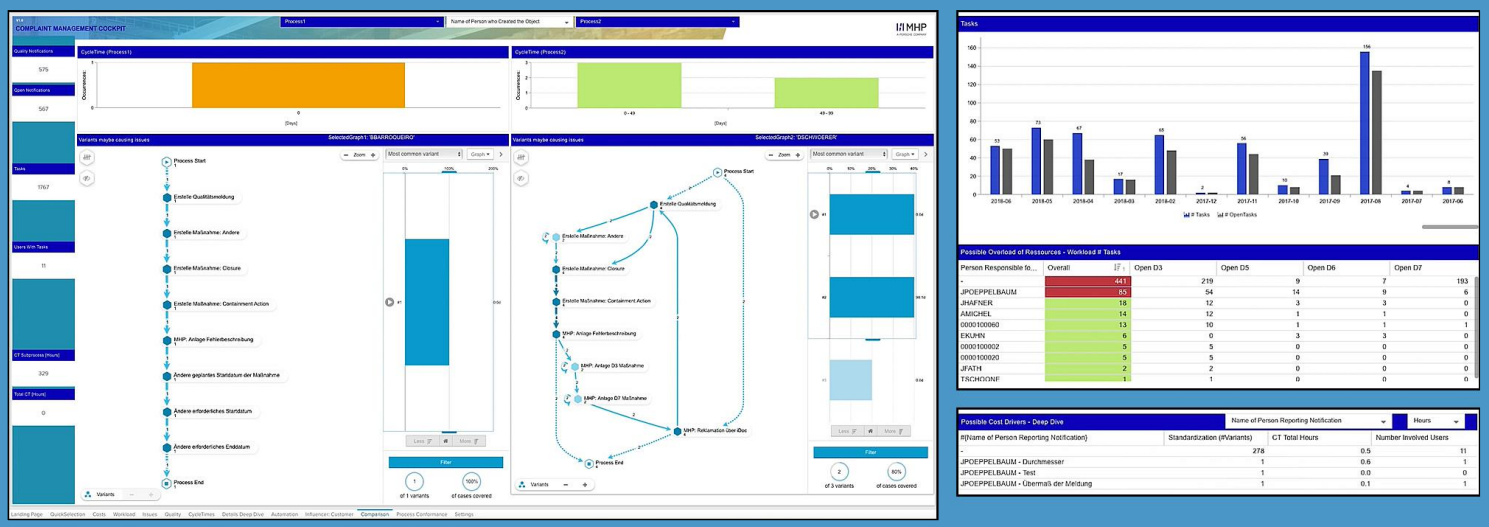

Figure 10: Singling out employees in manufacturing quality management (MHP/Celonis)[139]

In addition, the screen in figure 10 (left) shows Celonis' benchmarking functionality[140] that compares processes, work steps and metrics between two different subsets of cases. Both sides can be filtered by the name of the person who created a quality notification, which suggests that processes can be **analyzed at the individual level**, similar to the application described in section 4.1. On top, the screen displays the "cycle time", i.e. the average duration of the process for the cases shown on the benchmarking screen.

4.6 Process mining for HR and internal investigations

The Dutch IT consulting firm Process Minery[141] presents a "Timecard Process Cockpit" application on the Celonis website, which uses data from Oracle's human resource management system and Celonis technology to monitor and manage a timecard submission and approval process.[142]

Figure 11 (left) shows a typical process graph and a **list of named employees** who failed to submit their timecards to the HR department. It also displays a list of named supervisors, ranked by the number of supervised employees who failed to submit their timecards. The lists can be filtered by employee or supervisor. Another screen, as shown in figure 11 (right), **singles out employees** who had their timecards "corrected". In addition to a list and a chart that displays the number of corrected timecards per month, a ranking of named employees by the number of corrected timecards is available.

[139] Figures © MHP, Celonis. The figures serve as basis for the discussion of the corporate practices examined in this study. Sources: MHP Complaint Management Process Cockpit, Celonis "Partner Execution Instrument". Video stills min 3:12, 0:48, 0:30 https://www.celonis.com/ems/ems-store/mhp-complaint-management-process-cockpit/ [20.4.2023]

[140] See sections 2.3 and 4.1.

[141] https://www.processminery.com/ [18.4.2023]

[142] Process Minery Timecard Process Cockpit, Celonis "Partner Execution App": https://www.celonis.com/ems/ems-store/timecard-process-cockpit/ [8.7.2023]

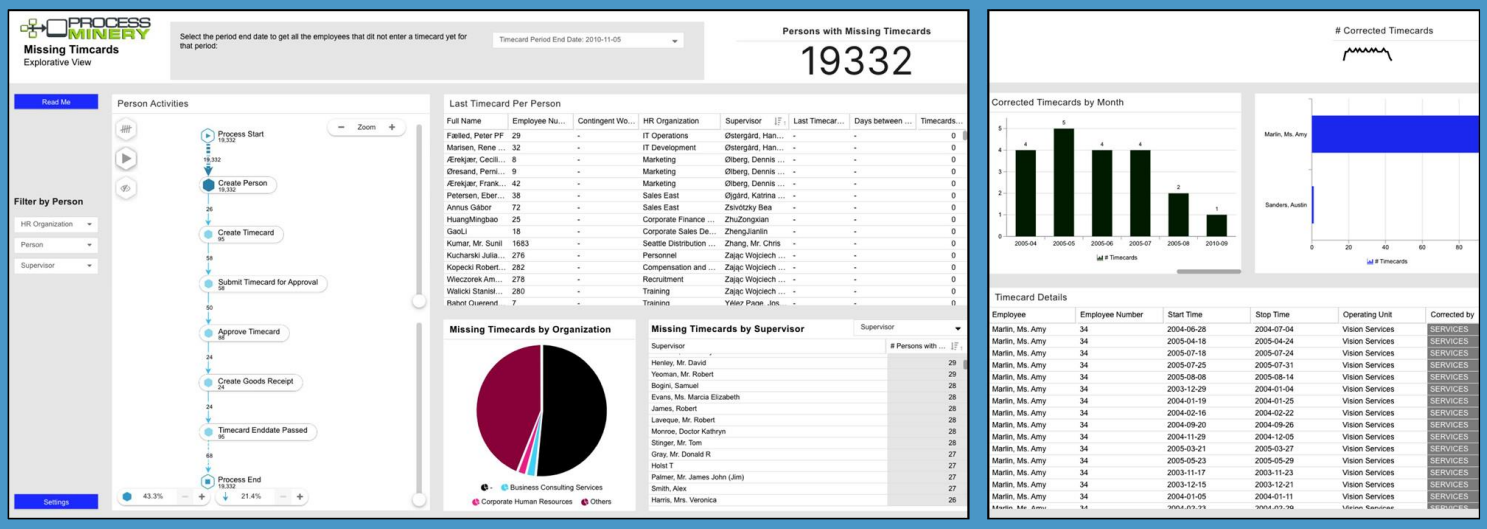

Figure 11: Singling out employees in HR (Process Minery/Celonis)[143]

This example shows, on the one hand, that Celonis' process mining system can be used to monitor and manage processes in a way that includes the ability to **display extensive personal data about employees** and the ability to **search for records at the individual level**. While displaying worker data and individual-level search could represent a legitimate use of Celonis' technology in this particular HR process, it may be problematic in other cases.

On the other hand, this particular example application, as presented on the Celonis website, is also worth further discussion. As singling out employees for policy violations or disciplinary misconduct is a highly sensitive process, it may be appropriate, for example, to redact employee names and numbers and only let supervisors take care of addressing issues at the individual level. Listing employees who had their timecards "corrected" suggests that the report is used for internal investigations by the HR or compliance department. Ranking supervisors by the number of supervised employees who failed to submit timecards is a form of **performance ranking**. These practices must be accompanied by strict procedures that prevent misuse of the data for other purposes.

4.7 Analyzing SAP activity records about individual employees

A product demonstration video by the consulting giant KPMG illustrates how Celonis' process mining technology can be used to analyze event log data, which includes personal data about employees, from the ERP system SAP.

Figure 12 (left) shows an analysis based on almost 1.6 million records about activities that were performed by 705 employees in the SAP system. The report contains a typical Celonis process graph and a "user activity" chart that displays aggregate information about the number of "cases" handled per day. But the displayed information can also be filtered by individual employees, as indicated by the element that makes it possible to "select a user" and choose a "user name".

In this example, the Celonis system processes 1.6 million records that contain personal data about employees and work activities carried out by them. In addition, the result of the analysis makes this data accessible **at the individual**

[143] Figures © Process Minery, Celonis. The figures serve as basis for the discussion of the corporate practices examined in this study. Source: Process Minery Timecard Process Cockpit, Celonis "Partner Execution App", https://www.celonis.com/ems/ems-store/timecard-process-cockpit/ [8.7.2023]

level. The report is titled "S/4 HANA User Adoption", which suggests that the "transaction analysis" serves to gain a better understanding about the adoption of a company's use of SAP's cloud-based ERP system.[144] It is questionable whether this purpose requires access to personal data about work activities at the individual level.

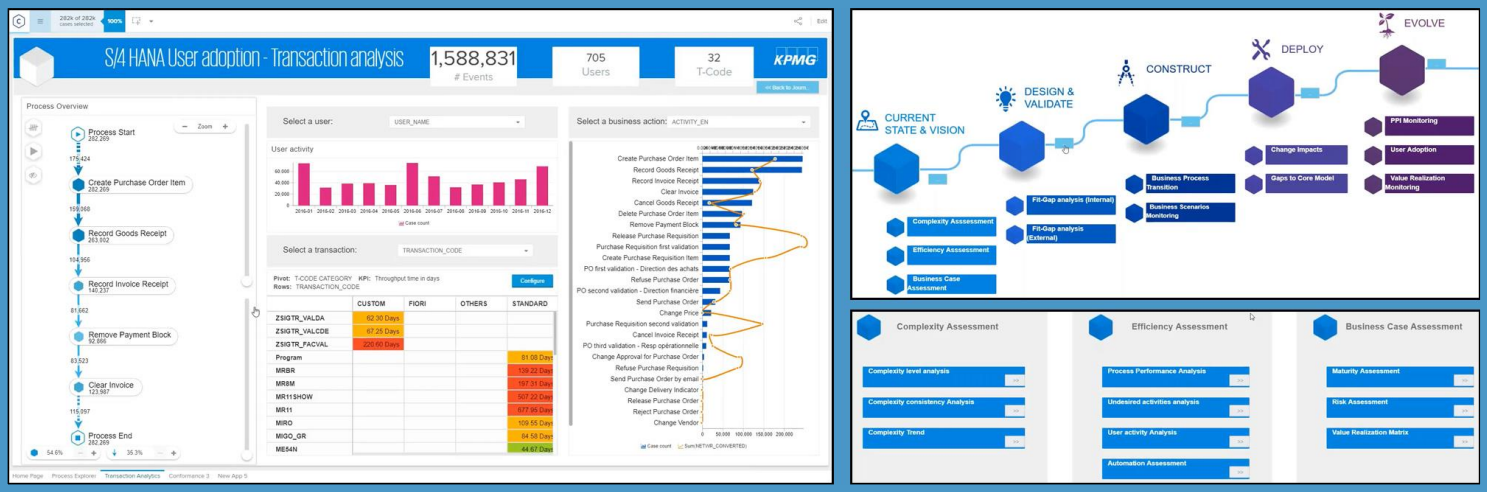

Figure 12: Analyzing SAP activity data at the individual level and (KPMG/Celonis)[145]

Efficiency assessment, process performance and "user activity analysis". According to the product demonstration video, this report is part of a variety of Celonis-based analyses that KPMG provides to clients who use SAP's cloud-based ERP system. As shown in figure 12 (top right), the "user adoption" analysis lies at the end of a series of steps, each of which consists of several analysis activities. Figure 12 (bottom right) shows a breakdown of the initial step, which consists of three substeps, which in turn each consist of several Celonis-based reports. The "efficiency assessment" includes the "process performance analysis", the "undesired activities analysis", the "automation assessment" and the "user activity analysis", the latter of which is not part of the product demonstration.

4.8 Analyzing the "people and their collaboration" behind the process

Celonis offers another module which it refers to as "PI Social", which promises to display information about the "activities, performance, and characteristics of the users involved in the analyzed process".[146]

As figure 13 (top left) shows, the "PI Social" module can display the "most frequently performed activities" by a "user" labeled "A". The screen, which is labeled "Performance of A", displays a chart that illustrates the activities performed on each day and other metrics. It also shows that the cases handled by user A come from a user B, which represents a form of social network analysis. Figure 13 (bottom left) displays a "daily profile" of user A in the form of a chart that shows which activities were performed at which time of day.

[144] https://www.sap.com/products/erp/s4hana.html [1.7.2023]
[145] Figures © KPMG/Celonis. The figures serve as basis for the discussion of the corporate practices examined in this study. Source: KPMG: Value Driven S/4 HANA Journey leveraging Celonis Process Mining, Celonis YouTube channel, 25.06.2019, min 30:50, 27:55, 27:48, https://www.youtube.com/watch?v=cryojQvUCtc [1.7.2023]
[146] https://docs.celonis.com/en/pi-social.html [8.7.2023]

Social analytics of groups and individuals. The example in the software documentation suggests that users "A" and "B" do not actually represent individual employees but two different groups of employees. As shown in figure 13 (top right), the database table that holds the records about cases and work activities includes a database column labeled "user type", which contains either the value "A" or the value "B". This database column was selected as the "user column" for the "PI Social" module. According to the documentation, the "user column" contains the "name or identification of the users who performed the activities" logged in the activity database table.[147] This suggests that the module can also be used to analyze behaviors of individual employees when the "user column" contains user identifiers of individual employees.

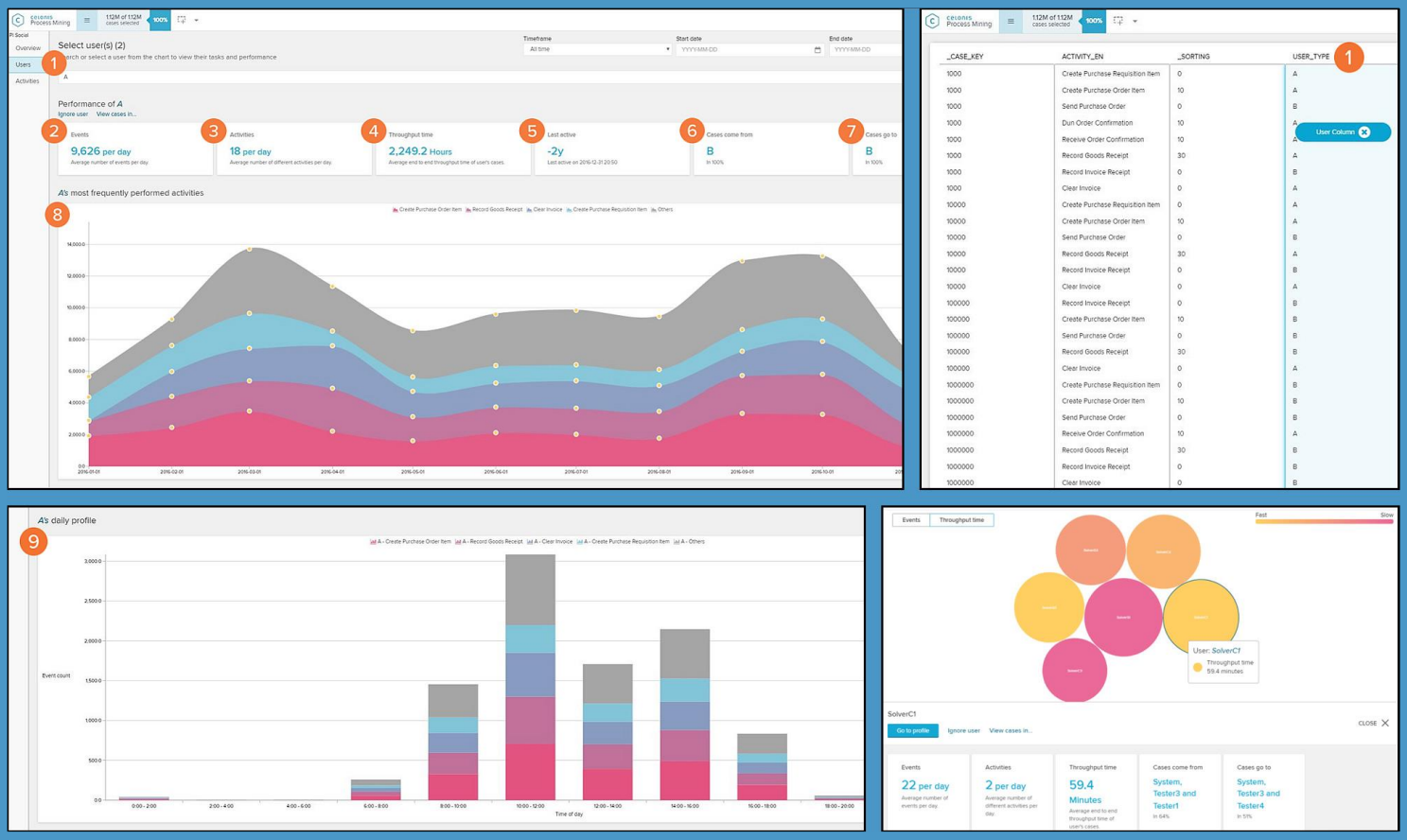

Figure 13: Analyzing the activities, performance and characteristics of users with "PI Social" (Celonis)[148]

Celonis also refers to the module as "social analytics", which makes it "possible to see the people and their collaboration behind the plain process".[149] According to a paper published by Celonis employees in 2017, the module "adds the social aspect of processes to Celonis". It visualizes the "network of social process interactions", "identifies

[147] https://docs.celonis.com/en/pi-social.html [8.7.2023]

[148] Figures © Celonis, David Karwehl. The figures serve as basis for the discussion of the corporate practices examined in this study. Sources: https://docs.celonis.com/en/pi-social.html [8.7.2023], Karwehl, David (2018): Use case based introduction to process mining and current tools. Bachelor thesis, p. 45: https://reposit.haw-hamburg.de/bitstream/20.500.12738/8424/1/thesis_David_Karwehl.pdf

[149] https://docs.celonis.com/en/execution-management-system--ems-.html [29.1.2023]

critical roles within the process, workload imbalances, and other team inefficiencies" and "uncovers issues in organizational structures and the interactions among people involved in the process".[150]

5. Analyzing screen, app, keyboard and mouse activities

The previous sections describe how the Celonis system can be used to analyze, optimize and manage processes based on time-stamped activity log data from different enterprise software systems, for example, based on transactional data about the time a certain invoice has been created, verified, rejected, confirmed or paid. Celonis offers another technology it refers to as "**task mining**", which can record and analyze almost any behavior observed on employee devices.[151] For this purpose, the employer installs a kind of spyware on the employees' desktop computers, which records fine-grained user interaction data about the use of Excel, SAP, email programs, web browsers and other applications, screen activities, clipboard contents, keyboard activities and mouse usage.

5.1 Recording screen, application, browser, keyboard and mouse data

Figure 14 (left) shows how Celonis' task mining software displays activity data captured from an employee's computer, including screenshots.

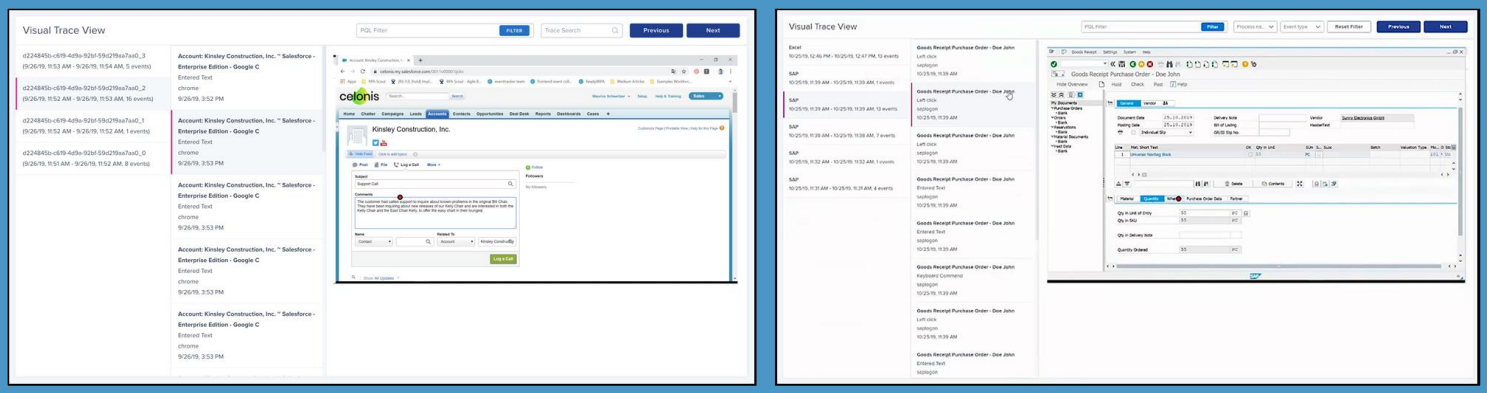

Figure 14: Recording screen, application, browser, keyboard and mouse activities (Celonis)[152]

In this example, the employee used the enterprise application Salesforce in the Chrome web browser and entered text in an online form. Each record displayed in the report includes a timestamp, the name of the application in use, the type of activity carried out, the title of the application or browser windows and a screenshot that shows all the details of the current browser window including the position of the mouse. Figure 14 (right) shows similar activity records of a person using the enterprise application SAP running in the browser, entering a keyboard command, entering text and clicking the left mouse button. Later, the person switched to Microsoft Excel. In this example, the system recorded 13 granular user interactions performed in a single SAP screen, then a single interaction in another

[150] Fabian Veit, Jerome Geyer-Klingeberg, Julian Madrzak, Manuel Haug, Jan Thomson (2017): The Proactive Insights Engine: Process Mining meets Machine Learning and Artificial Intelligence. Celonis SE, Munich, Germany, https://ceur-ws.org/Vol-1920/BPM_2017_paper_192.pdf

[151] https://docs.celonis.com/en/task-mining.html [19.6.2023]

[152] Figures © Celonis. The figures serve as basis for the discussion of the corporate practices examined in this study. Sources: https://www.celonis.com/intelligent-business-cloud/desktop-data-collection [27.10.2021], https://images.ctfassets.net/zmrtlfup12q3/1YUNd6valjCuPxI5NPbnAc/94a589582c698cfda04caee5c63a3fba/Visual_Trace_-_Task_Mining.png [18.4.2023]; Celonis & RPA - Automation Optimizer, Celonis YouTube Channel, min 3:17, https://www.youtube.com/watch?v=mP_yfoXjbnE [18.4.2023]

SAP screen and finally 13 user interactions in an Excel sheet. Celonis' technical documentation contains another example of this report, which displays both the username and the device name for each user interaction.[153]

The following list shows the types of data on user interactions and behaviors that can be recorded on an employee's computer, according to the software documentation:[154]

- **Basic event data:** event/activity type, timestamp, active Windows process, Windows username
- **Screen data:** filename of the screenshot related to the event
- **Keyboard data:** keyboard command, text entered
- **Copy/paste and clipboard data:** text selected for copy/cut, clipboard text content, content type
- **Mouse data:** x/y position, left or right click, name and type of the clicked element (e.g. button), number of units the mouse wheel was moved up or down
- **Application and active window data:** title of the active window, width/height, x/y coordinates, name/path of the application that has changed its state, application action
- **Browser data:** active or closed tab, URL of the website that triggered the event, detailed data about related HTML/DOM elements (e.g. form fields), clicked links, keyboard commands, entered text, text selections
- **Microsoft UIA application data:** detailed data about activities, user interface elements and the values they hold for applications that support Microsoft's "user interface automation" (UIA) standard
- **SAP data:** username, session ID, window name, SAP transaction ID, SAP screen number and detailed data about related user interface elements and activities such as mouse clicks, keyboard commands, entered text

The recorded data always includes a timestamp, the type of activity, the active Windows application and the username. Each user interaction record can also include additional details about the application currently in use, a screenshot and information about mouse clicks, keyboard inputs, copy and paste activities and the text content in the clipboard. Celonis task mining software can capture detailed interaction data from the web browser, including the current website URL and information about user interface elements such as buttons and form fields, the latter of which is also available for Windows applications that support Microsoft's "UI automation" functionality,[155] which should apply to most enterprise software. Recording data from the web browser captures user interactions in many cloud-based applications that are commonly used in the web browser.[156] For applications from the German enterprise software giant SAP, the system can capture additional details including the SAP username and information that describes SAP activities and procedures. All the captured data, including usernames and other personal identifiers, is accessible in the "live event monitor".[157]

Celonis emphasizes that the data collection abilities are customizable.[158] While capturing basic event data such as the timestamp, the type of activity, the active application and the username is mandatory, capturing all the other data types is optional. The system can optionally convert the Windows username into a non-readable "hashed" version. While doing so makes it more difficult to identify the person in the recorded data, "hashed" usernames are

[153] Ibid.
[154] https://docs.celonis.com/en/schema-documentation.html [19.6.2023]
[155] https://learn.microsoft.com/en-us/windows/win32/winauto/entry-uiauto-win32 [19.6.2023]
[156] See e.g. Rewatkar, Liladhar & Lanjewar, Ujwal (2010): Implementation of Cloud Computing on Web Application. International Journal of Computer Applications. 2. 10.5120/685-964.
[157] https://docs.celonis.com/en/live-event-monitor.html [19.6.2023]
[158] https://docs.celonis.com/en/schema-documentation.html [19.6.2023]

still pseudonymous personal data.[159] Several other data types are also "hashable". When capturing text entered by the user, employers can activate a setting that makes the system capture only the first character of the text.[160]

Capturing user interactions from employees' desktop computers. To record activity and interaction data, the employer must install the "task mining client", a Windows application provided by Celonis, on the employee's desktop computer.[161] It is "running in the background of a user's desktop, like anti-virus software, and is activated when a defined application is used".[162] To record more detailed information about web browser and SAP usage, employers can additionally install browser extensions for Chrome, Edge and Firefox and a specific data collection module for SAP.[163] Celonis emphasizes that its task mining system can be customized in order to limit the recorded data.[164] Employers can, for example, exclude certain applications from recording or define a list of applications to be recorded.[165] Before recording is started for the first time, it shows a configurable notice to the employee.[166]

In stark contrast to Celonis' claims about data protection, data minimization and privacy, which are further addressed in section 5.5, the company's marketing materials and technical documentation often mention the most intrusive data, from capturing "clicks and scrolls"[167] to accessing "user entered text".[168] When Celonis explains on its website "how task mining works", it suggests clients can "collect clicks, copy/pastes, time spent per application, and more — complete with time-stamps and screenshots".[169]

5.2 Analyzing application usage and work activities with "task mining"

"Task mining" is, according to Celonis, a "technology that allows businesses to capture desktop data, so they can analyze how their people are getting work done, and how they can do it even better".[170] It provides insight into work activities "including all the steps that happen outside of major systems", such as "checking an email", "consulting a spreadsheet",[171] "matching receipts to invoices in Adobe or spending ten minutes on LinkedIn to research a prospect".[172] Task mining "collects and aggregates data from employee desktop tasks and turns it into understandable behavioral patterns" to see "how employees' actions—on data entry screens, in email, spreadsheets, websites, and other tools—affect process outcomes".[173] According to Celonis, task mining can be used to "understand application usage and user behavior", "see where inefficiencies are occuring [sic] on desktops",[174] "decrease [the] amount of

[159] For "pseudonymous" data and "hashing" see e.g. section 2.7; Christl and Spiekermann (2016), p. 90.
[160] Ibid.
[161] https://docs.celonis.com/en/task-mining-desktop-application.html [19.6.2023]
[162] https://assets.ctfassets.net/zmrtlfup12q3/6TTqAlzjf2BnreVwLDxYzM/0325238e1162bf3aed80e9780c6e58e2/20210929-Task_Mining-Data-Protection-by-Design.pdf [19.6.2023]
[163] https://docs.celonis.com/en/data-collection-capabilities.html [19.6.2023]
[164] https://assets.ctfassets.net/zmrtlfup12q3/6TTqAlzjf2BnreVwLDxYzM/0325238e1162bf3aed80e9780c6e58e2/20210929-Task_Mining-Data-Protection-by-Design.pdf [19.6.2023]
[165] https://docs.celonis.com/en/configure-captured-applications.html [19.6.2023]
[166] https://docs.celonis.com/en/task-mining---configuration-editor.html [19.6.2023]
[167] https://docs.celonis.com/en/task-mining.html [19.6.2023]
[168] https://docs.celonis.com/en/web-page-data-extractions.html [19.6.2023]
[169] https://www.celonis.com/de/process-mining/what-is-task-mining/ [19.6.2023]
[170] https://docs.celonis.com/en/task-mining.html [19.6.2023]
[171] Ibid.
[172] https://www.celonis.com/de/process-mining/what-is-task-mining/ [19.6.2023]
[173] https://docs.celonis.com/en/glossary.html [19.6.2023]
[174] https://docs.celonis.com/en/task-mining.html [19.6.2023]

time spent on non-value adding activities" and "discover team training needs".[175] Overall, employers can "measure and optimize" their "workforce experience and productivity".[176]

User interactions and work activities. Figure 15 (left) shows an analysis of user interaction data. Similar to Celonis' process graphs based on transactional event log data (see section 2.3), it visualizes how users switched between Excel, Outlook, SAP and Salesforce in a particular operational process. The chart on the bottom left represents a breakdown of work activities performed by employees, including "confirming product availability", "researching consumer history" and "confirming credit worthiness".

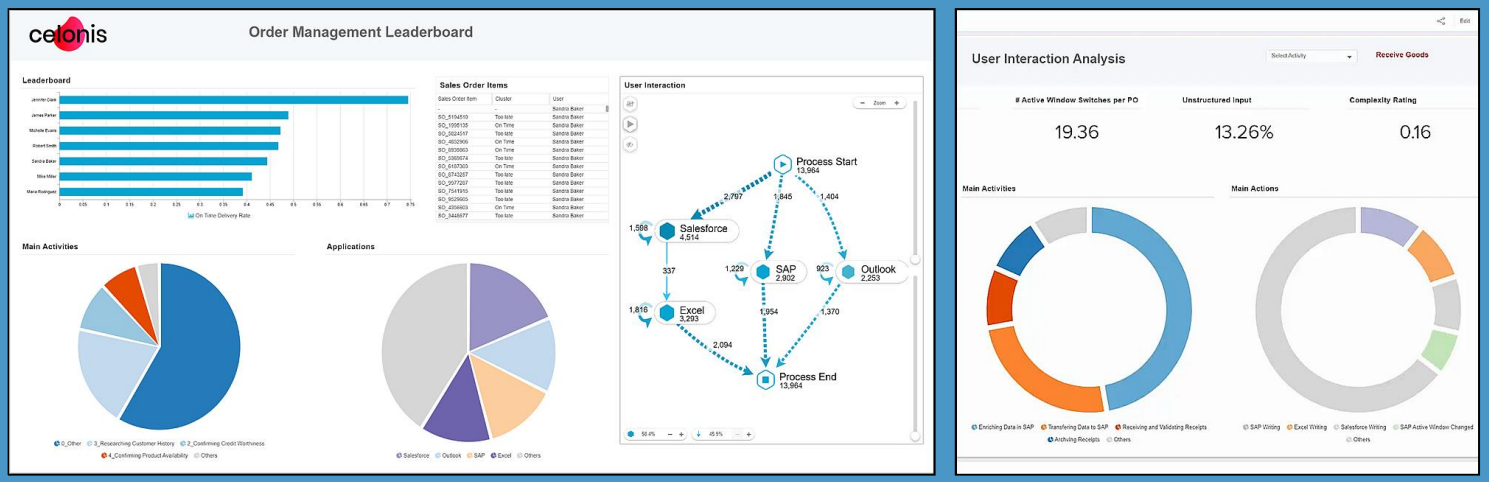

Figure 15: Analyzing application usage, work and "writing" activities; ranking employees (Celonis)[177]

Another example report in figure 15 (right) indicates that employees had been working on activities such as "transferring data to SAP", "enriching data in SAP" and "archiving receipts". The chart on the bottom right shows how much time they spent "writing" in Excel, Salesforce and SAP. In this example, employees switched the active window on their computer 19.36 times per purchase order ("PO") on average. It is noteworthy that the "order management leaderboard" in figure 15 also shows a performance ranking, which assesses individual employees according to the "on time delivery rate" of orders handled by them.

Time spent in applications and copy/paste behavior. Figure 16 shows reports from a product demonstration video published by Celonis in July 2022. These reports are more recent than the reports in figure 15, which appear to be between two and four years old.[178] Figure 16 (left) indicates that Celonis' task mining system was capturing 276,000 user interaction records from only four employees who used 43 different applications. The chart on the bottom left displays the minutes they spent in each application, such as Word, Excel, PowerPoint, Outlook and SAP. It also displays how long they were handling files in Windows Navigator and how much time they spent using Google

[175] https://www.celonis.com/de/process-mining/what-is-task-mining/ [19.6.2023]

[176] Ibid.

[177] Figures © Celonis. The figures serve as basis for the discussion of the corporate practices examined in this study. Sources: https://www.celonis.com/de/intelligent-business-cloud/desktop-data-collection/ [19.4.2022]; Celonis & RPA - Automation Optimizer, Celonis YouTube Channel, 18.11.2019, min 2:50, https://www.youtube.com/watch?v=mP_yfoXjbnE [18.4.2023]

[178] The source for the screenshot in figure 15 (right) is dated November 2019. The screenshot in figure 15 (left) was retrieved from the Celonis website in 2022, but might be older.

Search and visiting particular websites, such as answers.sap.com and sapfidocz.wordpress.com. The chart on the bottom right displays even more detailed information about activities performed in particular applications.

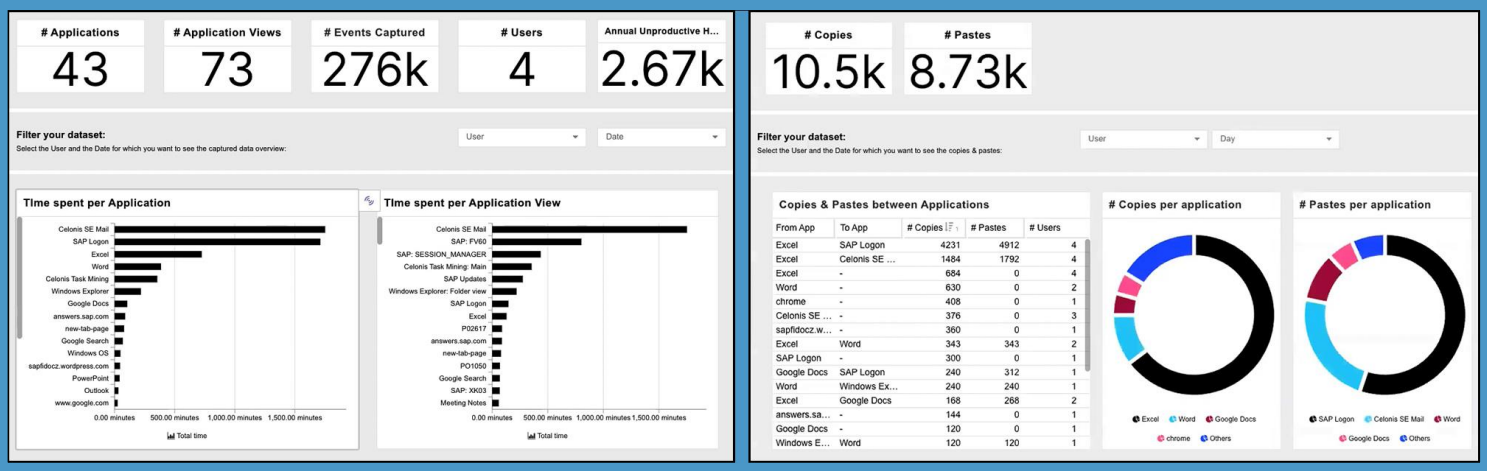

Figure 16: Analyzing the time spent in applications and copy/paste behavior (Celonis)[179]

Figure 16 (right) shows a detailed analysis of copy and paste activities, including a breakdown of how often the four employees, whose interaction data was recorded, copied data from one particular application to another application. In this example, they copied data from Excel 4,231 times and pasted it into SAP 4,912 times. Two employees copied data from Excel to Word 343 times and a single employee often copied data from Google Docs to SAP.

Aggregate and individual-level analysis? Even though the example report in figure 16 (right) exposes activity data about single employees, it generally displays aggregate information without naming any employee. Actual deployments in a company may collect interaction data from more than four employees. Nevertheless, this example indicates that the reports may display analysis results for small groups down to a single employee.

Strikingly, the example reports in figure 16 apparently also allow filtering of results by a particular employee. According to the labels, it is possible to "select a user and the date for which you want to see the captured data overview" and to "select a user and the date for which you want to see the copies & pastes". This suggests that these reports provide individual-level information about the "time spent per application", "copy & pastes between applications" and other metrics. A later version of a similar Celonis application from November 2022 does not allow filtering of results by particular employees, but only by particular "teams" (see section 5.3.3).

5.3 Task mining applications

Celonis describes different applications for its task mining system, which are further examined in the next sections.

[179] Figures © Celonis. The figures serve as basis for the discussion of the corporate practices examined in this study. Source: Demo | Optimize Workforce Productivity with Task Mining, Celonis YouTube channel, 12.7.2022, min 2:09 and 3:09, https://www.youtube.com/watch?v=WWXEj_eToKo [20.4.2023]

5.3.1 Combining task mining and process data

Task mining data captured from employees' desktop computers can be combined with process data based on transactional activity data from enterprise software, as described in sections 2 and 4.

For this purpose, the system tries, for example, to recognize particular numbers that appear in both the task mining and process data in order to **link records to each other**,[180] which Celonis refers to as "case matching".[181] It may, for example, detect invoice numbers, customer numbers or case IDs from records stored in an ERP system such as SAP in records captured by the task mining system,[182] for example, in the name of an Excel spreadsheet. As such, it can link the user interaction record captured by the task mining system to the activity record from the ERP system.

In addition, it is possible to use "optical character recognition" (OCR)[183] to **recognize numbers or activities in the screenshots** captured by the task mining system in order to "support the grouping of user interactions into activities" and match them with process activities.[184] The system may, for example, detect a customer number or case ID in a PDF document or email subject. Celonis also describes how to use timestamp information to correlate "desktop data with business data from transactional systems".[185] It may link records by detecting task and process activities that occur at the exact same time and which are performed by the same employee or share other characteristics.

Once records from task mining are linked to transactional records from enterprise software systems, the result can be further analyzed using the entire functionality for process analytics and optimization provided by Celonis, for instance, to "understand the impact of the desktop process on the business outcomes".[186] While it appears that Celonis has reduced the emphasis on this combination of task mining and process data in its marketing materials, which was much more prominently featured on its website until 2021,[187] it still promotes task mining as a solution to "enhance […] conventional process mining".[188] As detailed in section 5.3.4, a recent third-party application demonstrates a practical implementation of this combination of task mining and process data.

5.3.2 Task documentation

Celonis offers an extra module for "task documentation", which uses the task mining system to "capture the knowledge of how exactly a certain task is done and which steps it takes",[189] which results in process documentation

[180] https://assets.ctfassets.net/zmrtlfup12q3/70hMmS7qrVAuT9ZkaLxbSr/239a0c9b608fb66f2ea3ba53b332f760/Task_Mining_brochure-EN__2_.pdf, https://assets.ctfassets.net/zmrtlfup12q3/6TTqAlzjf2BnreVwLDxYzM/0325238e1162bf3aed80e9780c6e58e2/20210929-Task_Mining-Data-Protection-by-Design.pdf [19.6.2023]
[181] https://www.celonis.com/de/process-mining/what-is-task-mining/ [19.6.2023]
[182] https://assets.ctfassets.net/zmrtlfup12q3/6TTqAlzjf2BnreVwLDxYzM/0325238e1162bf3aed80e9780c6e58e2/20210929-Task_Mining-Data-Protection-by-Design.pdf [19.6.2023]
[183] See e.g. https://en.wikipedia.org/wiki/Optical_character_recognition
[184] https://assets.ctfassets.net/zmrtlfup12q3/6TTqAlzjf2BnreVwLDxYzM/0325238e1162bf3aed80e9780c6e58e2/20210929-Task_Mining-Data-Protection-by-Design.pdf [19.6.2023]
[185] https://assets.ctfassets.net/zmrtlfup12q3/70hMmS7qrVAuT9ZkaLxbSr/239a0c9b608fb66f2ea3ba53b332f760/Task_Mining_brochure-EN__2_.pdf, https://assets.ctfassets.net/zmrtlfup12q3/6TTqAlzjf2BnreVwLDxYzM/0325238e1162bf3aed80e9780c6e58e2/20210929-Task_Mining-Data-Protection-by-Design.pdf [19.6.2023]
[186] https://assets.ctfassets.net/zmrtlfup12q3/6TTqAlzjf2BnreVwLDxYzM/0325238e1162bf3aed80e9780c6e58e2/20210929-Task_Mining-Data-Protection-by-Design.pdf [19.6.2023]
[187] https://web.archive.org/web/20211027125024/https://www.celonis.com/intelligent-business-cloud/desktop-data-collection [19.6.2023]
[188] e.g. in this video from November 2022, min 21:20: https://www.celonis.com/solutions/workforce-productivity/?modalId=3xBODbF9lAVzaa8i5d7Os5 [19.6.2023]
[189] https://docs.celonis.com/en/task-mining---getting-started-with-task-documentation.html [19.6.2023]

in common formats,[190] such as "Standard Operating Procedures (SOPs), Process Definition Documents (PDDs) or Level 4/5 documentation". According to Celonis, this technology replaces manual task documentation by business analysts who conduct interviews with employees and take notes about work steps.[191]

A product demonstration video on the Celonis website shows that the task documentation module displays process graphs, screenshots and other details based on data captured by the task mining system. According to Celonis, it aims to "find improvement potential across teams [or departments] and not to monitor any particular employee" and can also be used for training purposes or "automation initiatives".[192]

5.3.3 Task mining for "workforce productivity"

In November 2022, Celonis announced[193] an application it refers to as "workforce productivity", which is a system that displays reports about application usage, copy and paste activities and other information based on task mining data. It promises to help employers understand "how productive" their employees are and "how much time they spend being productive during an average day".[194] In the technical documentation, Celonis even recommends setting up its entire task mining system by initially installing the "workforce productivity" application,[195] which would require "less than 10 minutes".[196]

It is remarkable that Celonis puts so much emphasis on the analysis of "workforce productivity" as a major use case for its highly intrusive task mining technology. The company uses aggressive slogans to market the application, which can sound contradictory at times. Employers can, for example, "gain full workforce visibility with privacy". They can also "investigate application usage on a granular application-window level", "understand changing behaviors as they happen"[197] and even "compare users".[198]

Analyzing application usage. Figure 17 shows parts of the user interface as presented on the Celonis website and in a product demonstration video. In this example, the task mining system captured almost 70 million user interactions performed by 1,004 employees, who had their desktop computers monitored for 20,199 hours and 11 minutes over four days (figure 17, top left). Several charts show how many minutes employees spent browsing particular websites, such as mail.google.com and research.multiple.com, and how much time they spent using particular applications, such as an email program, Word, Excel, Google Docs, Zoom, Slack, Windows Explorer and SAP (figure 17, top center+right). This includes information on the time spent with particular "application views", i.e. with particular Excel files or particular SAP functionality (figure 17, top right).

Another report displays how often employees performed particular activities in specific applications. The system recorded, for example, 4.8 million occurrences of employees "typing" in the email program and 5.8 million occurrences of them using a "keyboard command". While they viewed or edited Excel files 7.5 million times, the "clicking" activity in SAP was captured 4.5 million times.

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[190] See e.g. https://en.wikipedia.org/wiki/Standard_operating_procedure, https://en.wikipedia.org/wiki/Process-data_diagram, https://en.wikipedia.org/wiki/Business_process_mapping
[191] https://docs.celonis.com/en/task-mining---getting-started-with-task-documentation.html [19.6.2023]
[192] Ibid.
[193] https://www.celonis.com/blog/celonis-workforce-productivity-enables-end-to-end-process-employee-experience-improvement/ [19.6.2023]
[194] https://docs.celonis.com/en/task-mining-workforce-productivity-quickstart--template-.html [19.6.2023]
[195] https://docs.celonis.com/en/set-up-task-mining.html [19.6.2023]
[196] https://docs.celonis.com/en/task-mining-workforce-productivity-quickstart--template-.html [19.6.2023]
[197] https://www.celonis.com/solutions/workforce-productivity/ [19.6.2023]
[198] https://docs.celonis.com/en/task-mining-workforce-productivity-quickstart--template-.html [19.6.2023]

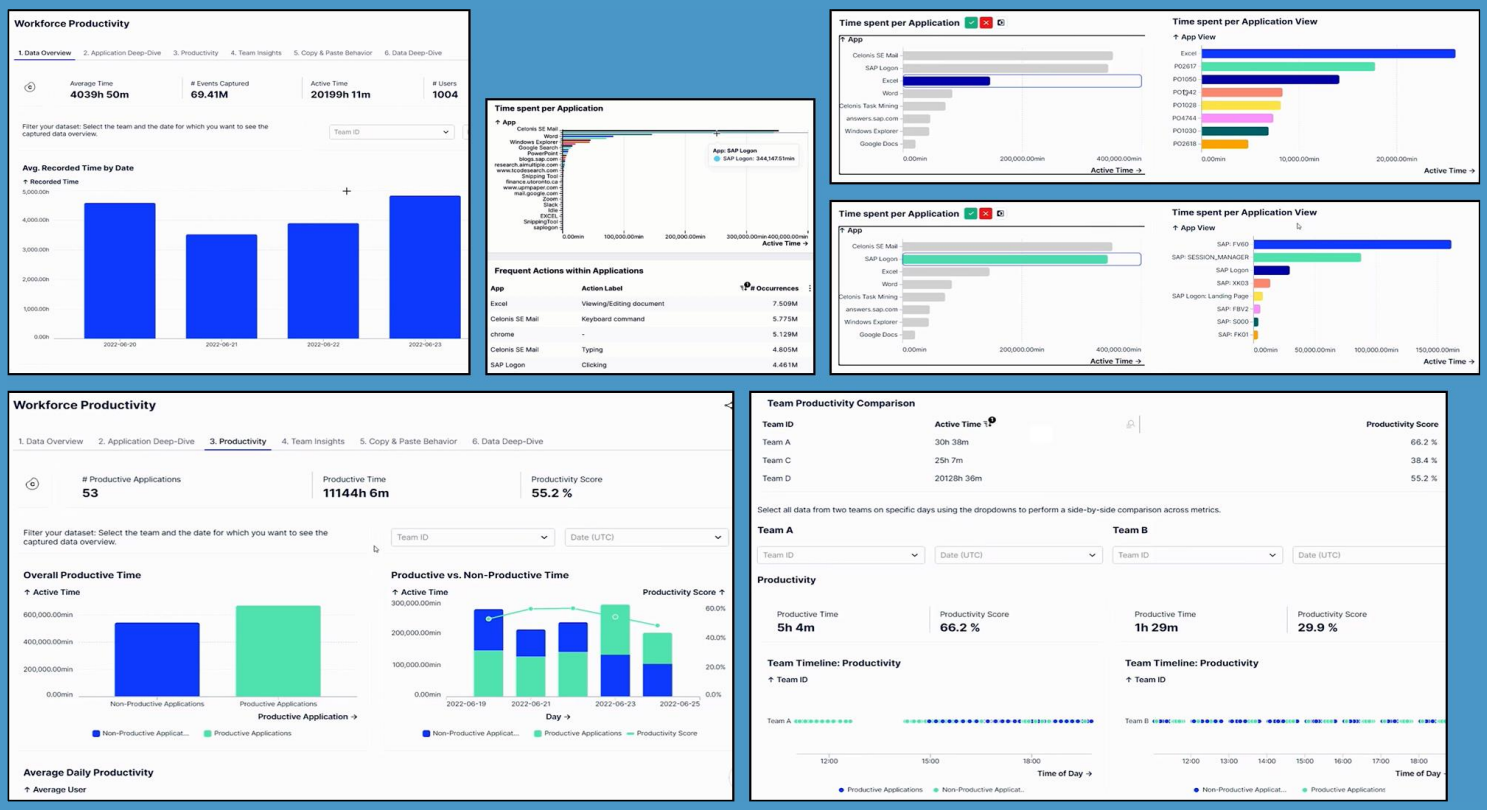

Figure 17: A "workforce productivity" application based on "task mining" (Celonis)[199]

Celonis explains that the system can record up to 1.6 billion interactions from 2,500 employees over six months.[200] Irrespective of whether the analysis results display personal data, this involves the processing of personal data about employee behavior at a massive scale.

"Productive" and "unproductive" time. The "workforce productivity" system also claims to assess whether using a particular application is considered "productive" or "unproductive" time, based on user interactions recorded from employees' desktop computers. In this example, only 11,144 hours are considered "productive time" out of a total of 20,199 hours of interactions captured from 1,004 employees over four days (figure 17, bottom left). As a result, only about 55% of the overall time employees spent using their desktop computer was assessed as "productive", which Celonis refers to as the "productivity score". According to a product demonstration video, "productive applications are defined out of the box by Celonis", but employers can "easily change them".[201]

Comparing "productivity" between teams. As figure 17 (bottom right) shows, the system also displays a "side-by-side comparison" of productive times and productivity scores for particular teams. In this example, a group of employees labeled "Team A" was assessed to have a productive time of 5 hours and 4 minutes, resulting in a productivity score of 66.2%. Another group labeled "Team B" was considered productive only for 1 hour and 29

[199] Figures © Celonis. The figures serve as basis for the discussion of the corporate practices examined in this study. Sources: Top/center: https://www.celonis.com/solutions/workforce-productivity/ [21.4.2023]; other images: Celosphere 2022, Task Mining: Striking productivity gold, Nov 2022, video on Celonis website, min 9:49, 12:50, 12:14, 10:12, 10:43, 10:59, https://www.celonis.com/solutions/workforce-productivity/?modalId=3xBODbF9lAVzaa8i5d7Os5 [20.4.2023]

[200] https://docs.celonis.com/en/workforce-productivity--powered-by-task-mining----increased-scalability.html [19.6.2023]

[201] Video from min 10:00: https://www.celonis.com/solutions/workforce-productivity/?modalId=3xBODbF9lAVzaa8i5d7Os5 [19.6.2023]

minutes, resulting in a productivity score of 29.9%. According to Celonis, this functionality enables employers to "investigate differences among a subset of users"[202] and "locate potential optimization opportunities while keeping individual users still de-identified".[203] To "keep users de-identified", companies should ensure that "more than e.g. 5 users are in the team or per individual attribute value".[204]

Celonis provides **inconsistent information** about whether reports from its task mining system display individual-level data or strictly aggregate and group-level data only. A product demonstration video from July 2022 shows a version of the "workforce productivity" application that allows analysis results to be filtered by particular employees, as detailed in figure 16 (section 5.2). So does a product demonstration video from 2021.[205] According to the product demonstration video from November 2022, as shown in figure 17, the analysis results can be filtered by teams only. It is not clear whether the older version is still available or how it has been used by employers. The Celonis-based task mining application provided by IBM described in section 5.3.4 also allows filtering results by individual users.

5.3.4 Analyzing application use, productivity and "idle time" at the individual level

IBM presents a task mining application on the Celonis website that it refers to as "Process Excellence (PEX) for Task Mining".[206] Based on Celonis' task mining system, it promises to measure KPIs related to "efficiency", "task productivity", "compliance" and "idle time" (figure 18, left).

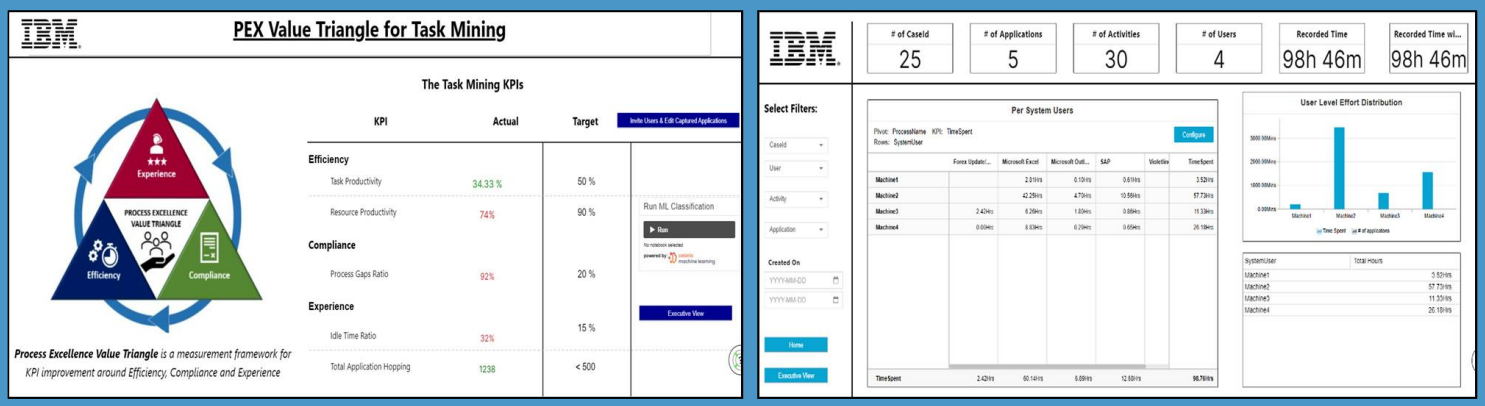

Figure 18: Analyzing application use, compliance, task productivity and "idle time" (IBM/Celonis)[207]

For this purpose, it tracks the use of applications on employees' desktop computers and links the captured task mining data to "cases" in process mining data captured from transactional data in an undisclosed enterprise software system. As figure 18 (right) shows, this example system recorded data from four employees who used five different applications on their desktop computers for 98 hours and 46 minutes in total. The system identified 30 different

[202] https://docs.celonis.com/en/task-mining-team-insights.html [19.6.2023]
[203] Video from min 11:00: https://www.celonis.com/solutions/workforce-productivity/?modalId=3xBODbF9lAVzaa8i5d7Os5 [19.6.2023]
[204] https://docs.celonis.com/en/task-mining-team-insights.html [19.6.2023]
[205] Video from min 2:50: https://www.youtube.com/watch?v=NHbRfT9-L1g [19.6.2023]
[206] https://www.celonis.com/ems/ems-store/process-excellence-for-task-mining/ [21.6.2023]
[207] Figures © IBM/Celonis. The figures serve as basis for the discussion of the corporate practices examined in this study. Source: IBM - Process Excellence (PEX) for Task Mining, Celonis "Partner Execution App": https://www.celonis.com/ems/ems-store/process-excellence-for-task-mining/ [21.6.2023]

work activities and linked them to 25 cases in the transactional process data. The table at the center provides information about the time spent with Excel, Outlook, SAP and other applications per "machine". According to the website,[208] executives can use "machine level details" to "track which users might need training or support to reduce operational costs and which applications are mostly used", which suggests that a "machine" refers to a device used by a particular employee. The chart on the right in figure 18 (right) is labeled "user level effort distribution" and shows the overall time spent on the five applications for each "machine" used by an employee. While "machine" or "user" identifiers such as "Machine1" are still pseudonymous data, the report clearly displays **individual-level personal data** on application usage and **rates individuals** according to the time spent with these applications.

The report shown in figure 19 (left) provides more detailed information about activities performed in particular applications and distinguishes between activities linked to "cases" in the process data and activities not linked to cases. In addition, it displays a detailed breakdown of "case related time spent by activity". Employees spent, for example, 111.05 minutes in Excel performing a particular activity linked to 11 cases, 13.14 minutes in the Google Chrome browser performing a particular activity linked to two cases and 0.08 minutes in the Microsoft Edge browser performing a particular activity linked to a single case in the process data. The panel on the left indicates that the records shown in the report can be filtered by individual "user" and can thus display all the analysis results **at the individual level**. Filtering per individual appears to be possible across several of the application reports.

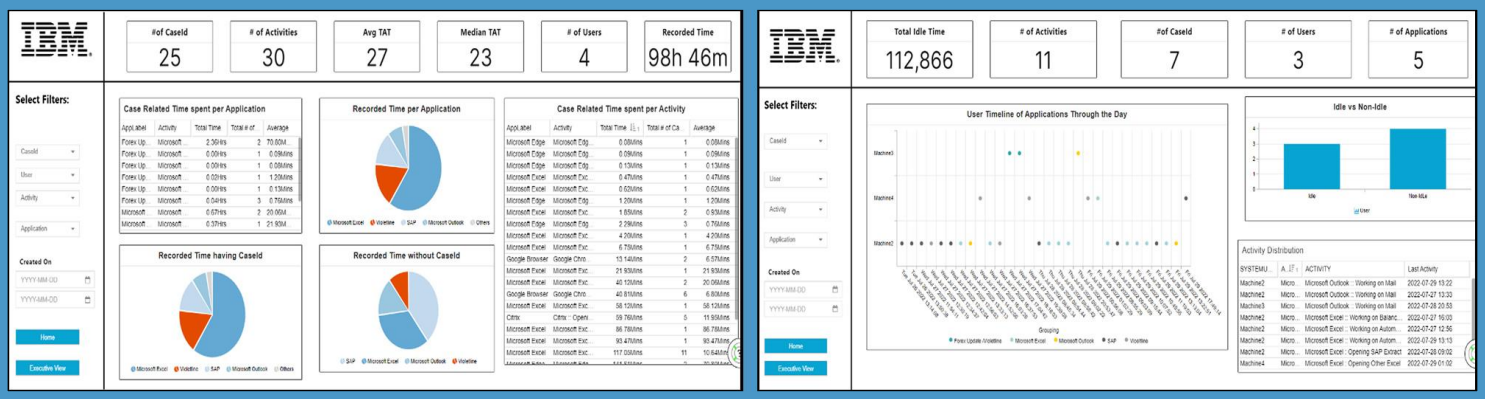

Figure 19: Analyzing application use and "idle time" at the individual level (IBM/Celonis)[209]

Assessing "idle" time. The system displays individual-level information about the time spent in applications that are considered "idle time", probably because they are not linked to cases in the process data. Figure 19 (right) shows a chart that compares "idle" time and "non-idle" time. Once again, the report can be filtered by individual users. In addition, the report displays a "user timeline of applications through the day" per "machine" and a list of activities such as "Working on Mail" in Outlook, "Opening SAP Extract" in Excel and "Opening other Excel", including a "last activity" timestamp and information about the corresponding "machine". The report in this example suggests that only three out of four employees had "idle time" at all.

[208] Ibid.

[209] Figures © IBM/Celonis. The figures serve as basis for the discussion of the corporate practices examined in this study. Source: IBM - Process Excellence (PEX) for Task Mining, Celonis "Partner Execution App": https://www.celonis.com/ems/ems-store/process-excellence-for-task-mining/ [21.6.2023]

Efficiency, task productivity and process compliance. As shown in figure 18 (left), the system calculates aggregate "task mining KPIs" from the captured data, which are compared to desired targets. The report provides "executives and management with an easy to read, quick view of KPI achievement".[210] In this example, the four employees' overall "task productivity", which describes their "efficiency", is assessed to be 34.33%, compared to a target value of 50%. Instead of meeting the expected "idle time ratio" of 15%, their actual idle time is assessed to be 32%. The system also indicates a lack of "compliance", which refers to "noncompliance flows where events are missing" or "unusual events" in the "process flows", according to the website.[211] This lack of "compliance", which is expressed by the "process gaps ratio", is assessed to be 92%, which is a major deviation from the target value of 20%. Actual KPI values that deviate from the expected target values are displayed in red, indicating a need for action.

The examination of this IBM application suggests that Celonis' task mining system can be used for performance monitoring at both the group and individual level.

5.4 Practical use?

While capturing behavioral data from desktop computers can generally be considered intrusive, Celonis' task mining system can certainly be used in different ways. According to the company, it is "built to support the optimization of processes - in the context of a defined project period and in close cooperation with the involved employees".[212]

Small and large-scale uses. The consulting giant Deloitte, for example, explains in a promotional article how it deployed task mining at a "large international toy manufacturer".[213] They had a "sample size of 40 users willing to be in the task mining study for a minimum of 10 working days". The study examined a particular operational process and took various measures to ensure "that the analysis did not pinpoint individual performance issues or individual people". According to the article, "task mining based on actual data recorded from the human user activity on the desktop" surpassed "traditional consulting methods such as time-in-motion studies and questionnaires" for "accuracy, quality and speed of implementation". According to another example mentioned in a promotional video from Celonis, a "multi-billion telecommunications company" used the task mining system to analyze and optimize a "claim management process" handled by call center workers and then decided to roll it out to a "department" of more than 2,000 employees.[214] In 2023, Celonis announced that the system is now able to capture up to 1.6 billion interactions from 2,500 employees over six months.[215]

5.5 Data protection, privacy and employee "consent"

Celonis' task mining system potentially collects fine-grained behavioral data from employees' desktop computers over days, weeks or longer periods of time. As the captured data always includes the Windows username (see section 5.1), it collects extensive personal data on employees, irrespective of whether the included identifiable information is pseudonymized or not (see section 2.7). The system can be considered especially intrusive when it is used to collect data on almost every activity performed by an employee over the whole day, including user interactions with

[210] https://www.celonis.com/ems/ems-store/process-excellence-for-task-mining/ [21.6.2023]
[211] Ibid.
[212] https://assets.ctfassets.net/zmrtlfup12q3/6TTqAlzjf2BnreVwLDxYzM/0325238e1162bf3aed80e9780c6e58e2/20210929-Task_Mining-Data-Protection-by-Design.pdf [22.6.2023]
[213] https://www.celonis.com/blog/deloitte-deep-dive-combining-celonis-process-mining-and-task-mining-to-drive-productivity/ [22.6.2023]
[214] Video from min 20:00: https://www.celonis.com/solutions/workforce-productivity/?modalId=3xBODbF9lAVzaa8i5d7Os5 [22.6.2023]
[215] https://docs.celonis.com/en/workforce-productivity--powered-by-task-mining----increased-scalability.html [19.6.2023]

applications, email programs and web browsers, or when it captures even clipboard contents, keyboard and mouse activities and screenshots. As the previous sections show, several example applications based on task mining use highly sensitive data. In some cases, they even display individual-level data in reports and analysis results.

Celonis provides an extra document about its task mining system and "data protection by design", focusing on Europe and the GDPR.[216] The document claims that the system is "designed and developed with a focus on data protection principles", but emphasizes that Celonis is "not providing any legal advice". To minimize the captured data, employers can include or exclude particular applications from being tracked and can customize the captured data categories. They can, for example, "deactivate text input and screenshots". They can use pseudonymization and hashing (see section 5.1) for both identifiable attributes and text content. The document also briefly addresses fundamental data protection principles, such as purpose limitation, lawfulness, fairness, transparency.

Notice and "consent". The current version of Celonis' task mining system appears to require employees to confirm a customizable "privacy" notice before any data is captured from their desktop computer. As figure 20 (left) shows, Celonis suggests that employers should include information about the purpose and the legal basis of processing, the latter of which could be "consent", "employment contract" or "legitimate interest". In the documentation, the notice is referred to as "consent text", and the checkbox shown below is referred to as "consent checkbox".[217]

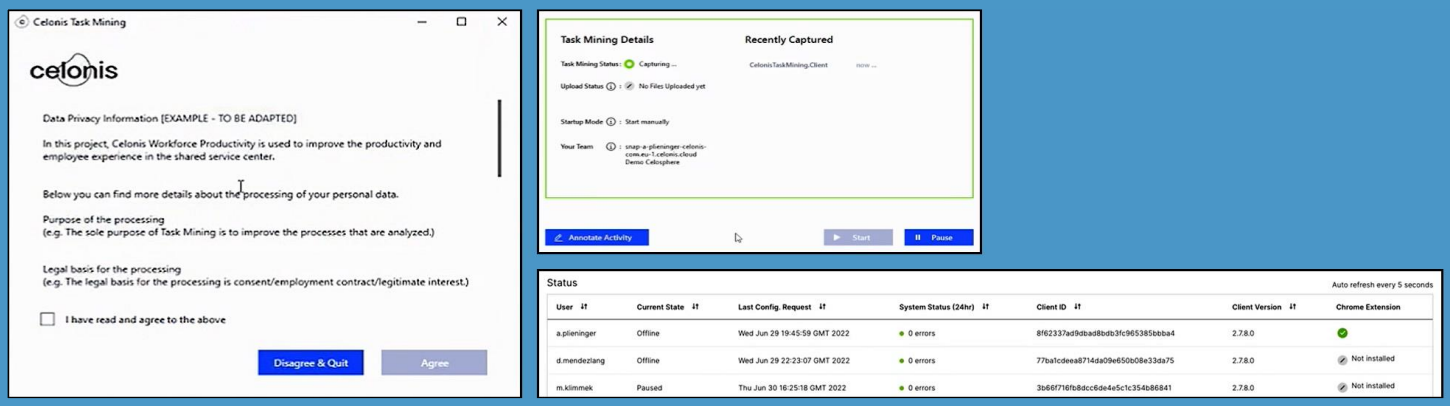

Figure 20: Employee 'consent' for task mining and the list of monitored employees (Celonis)[218]

Relying on employee consent, including via a clause in the employment contract, is generally difficult under the GDPR, if not almost impossible.[219] Relying on the employer's legitimate interest is at least questionable, but this depends on many factors. Employment laws in different European countries may also restrict or make it impossible to use Celonis' task mining system. A comprehensive legal assessment of Celonis' software is beyond the scope of this case study, however.

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[216] https://assets.ctfassets.net/zmrtlfup12q3/6TTqAlzjf2BnreVwLDxYzM/0325238e1162bf3aed80e9780c6e58e2/20210929-Task_Mining-Data-Protection-by-Design.pdf [21.6.2023]

[217] https://docs.celonis.com/en/task-mining---configuration-editor.html [21.6.2023]

[218] Figures © Celonis. The figures serve as basis for the discussion of the corporate practices examined in this study. Sources: Celosphere 2022, Task Mining: Striking productivity gold, Nov 2022, video on Celonis website, min 8:53 and 9:10, https://www.celonis.com/solutions/workforce-productivity/?modalId=3xBODbF9lAVzaa8i5d7Os5 [20.4.2023]; Demo | Optimize Workforce Productivity with Task Mining, Celonis YouTube channel, 12.7.2022, min 0:29, https://www.youtube.com/watch?v=WWXEj_eToKo [20.4.2023]

[219] See e.g. https://commission.europa.eu/law/law-topic/data-protection/reform/rights-citizens/how-my-personal-data-protected/can-my-employer-require-me-give-my-consent-use-my-personal-data_en [21.6.2023]

Installation on employee computers. It appears that the current version of the task mining system cannot be installed on an employee's desktop computer without them at least being exposed to a notice as described above. The Windows client software, including the browser extensions for Chrome and Edge, can be installed remotely,[220] but will not capture data unless "the user previously accepted the legal terms".[221] It can be configured to start automatically "with a minimized application window", but "clicking the system tray icon" restores the full application window,[222] which enables users to "pause" data collection, as shown in figure 20 (top right). When users pause data collection, this is, however, visible in the system's status report. Figure 20 (bottom right) shows a status report that displays a list of employees including their username, the installed browser extensions and information about whether they have "paused" data collection or are "offline". Adding an employee to the list of individuals whose desktop computer is being tracked is referred to as "invite[ing] users to capture data".[223] Optionally, the system can be configured to ask participating employees to select their team, region and role from predefined lists, which is then used for the group-level analysis.[224]

In the documentation for its "workforce productivity" app (see section 5.3.3), Celonis states that clients are "advised to consult" their "data privacy experts before activating Task Mining" and to "support the implementation" by "organizational measures (e.g. internal communication, alignment with workers council - if applicable)". While this statement is hidden on a sub-page, the main documentation page suggests that employers can "get started" setting up the app "in less than 10 minutes", which includes a "seamless installation and invite flow" and "expand[ing] Task Mining across an organization". These recommendations are, to put it mildly, somewhat contradictory.

6. Automating processes, workflows and task assignment

The previous sections examined and documented how Celonis' technology can be used to analyze, optimize and manage operational processes and work activities based on extensive data from different enterprise software systems, which can involve individual-level performance monitoring and capturing behavioral data from desktop computers. This section addresses Celonis' offers and promises related to "automation", a term that appears often in the company's software documentation and marketing materials,[225] including the automation of processes, workflows and activities across different enterprise software systems and the automated assignment of tasks to workers.

6.1 Measuring and assessing the degree of process automation

As detailed in sections 2-4, Celonis' process mining software analyzes every step involved in handling a "case", such as an insurance claim, customer service request, warehouse delivery item, manufacturing unit or creative task. The system displays a graph that shows all occurring steps and "variants" of an operational process, which are put in relation to KPI metrics that track time, cost, productivity, efficiency and other measures. It shows, for example, the average time it takes to handle an insurance claim, from a customer filing the claim to its resolution, and measures that indicate how many claims go through work steps that are considered undesirable and inefficient. These KPI metrics can be displayed either for all processed cases or for a subset of cases that go, for example,

[220] https://docs.celonis.com/en/centralized-admin-rollout-options.html [21.6.2023]
[221] https://docs.celonis.com/en/task-mining---configuration-editor.html [22.6.2023]
[222] Ibid.
[223] https://docs.celonis.com/en/task-mining-workforce-productivity-quickstart--template-.html [22.6.2023]
[224] https://docs.celonis.com/en/task-mining-team-insights.html [22.6.2023]
[225] According to Google search results and as of 26.6.2023, the celonis.com website includes 3,320 pages that contain the phrase "automation".

through a certain process step or are handled by a certain department. In addition, the system can display measures that describe which process steps are performed manually by employees and which steps are performed automatically by a software system in order to assess the degree of automation and uncover steps that could be automated.

Assessing automation rates. Figure 21 shows a process that describes how a company buys goods and services, from an employee or department requesting a purchase to sending the order, receiving the goods and booking the invoice. In this example from a product demonstration video by Celonis,[226] records on 1,116,080 purchase orders are analyzed, which go through 655 different process variants. The report in figure 21 (left) shows the steps in the most common process variant. For each step, the report assesses how many times the activity was performed manually by an employee ("manual rate") and how often it was handled automatically by a software system ("backend automation rate", "robot rate"). In addition, it claims to rate the "complexity" of each step.

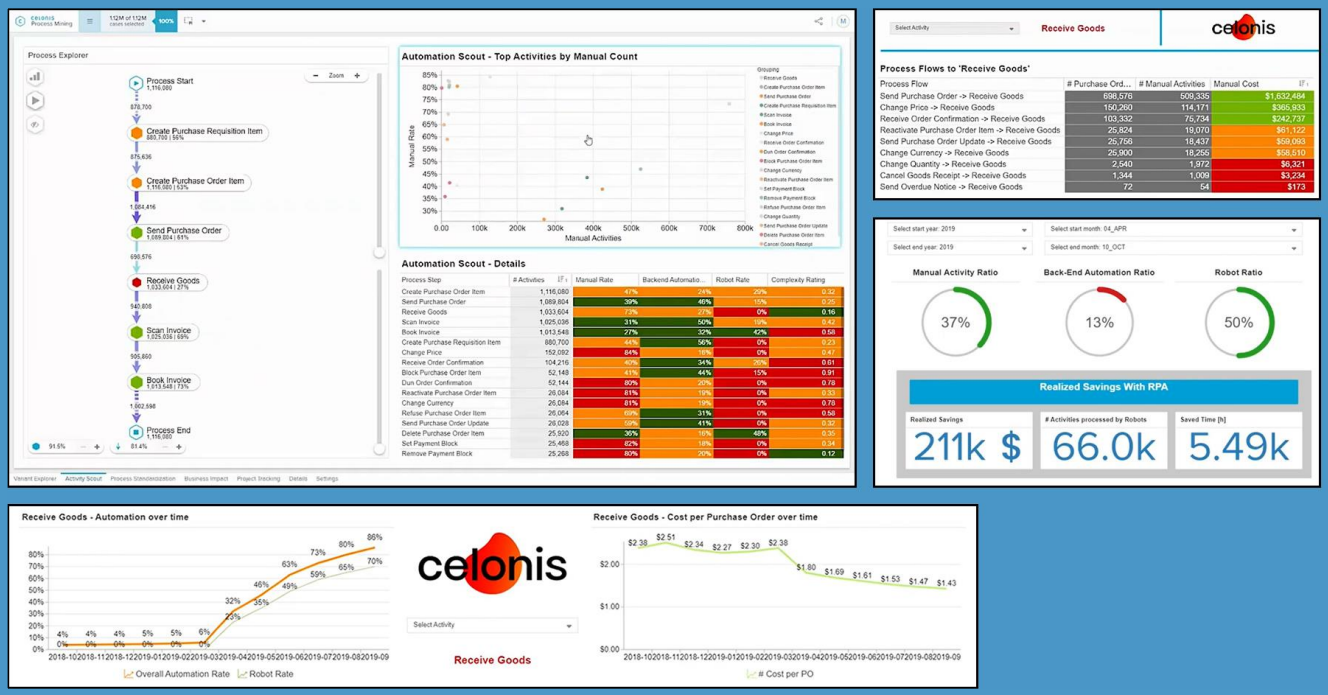

Figure 21: Measuring and rating the degree of process automation (Celonis)[227]

The report shows, for example, that the process step "scan invoice" was performed 1,025,036 times. While scanning the invoice was performed manually by an employee in 31% of the cases, this activity was handled by an "backend automation" system in 50% of the cases and by a "robot" system in 19% of the cases.[228] The complexity rate of this step was assessed to be 0.42.

Assessing cost savings through automation. Celonis also outlines the personnel costs associated with manually performed activities and the cost savings achieved through automation. As shown in figure 21 (top right), the transition from the process step "send purchase order update" to the step "receive goods" was performed 25,756 times,

[226] Video from min 0:49: https://www.youtube.com/watch?v=mP_yfoXjbnE [26.6.2023]
[227] Figures © Celonis. The figures serve as basis for the discussion of the corporate practices examined in this study. Source: Celonis & RPA - Automation Optimizer, Celonis YouTube channel, 18.11.2019, min 1:44, 2;19, 3:22, 3:22, https://www.youtube.com/watch?v=mP_yfoXjbnE [22.6.2023].
[228] While "backend automation" refers to the automation of activities across networked software systems, "robot" automation refers to systems for "robotic process automation", as detailed in section 6.2.

of which 19,070 were performed manually, which resulted in personnel costs of $59,053. As figure 21 (bottom right) indicates, automating 66,000 activities previously performed by employees who spent 5,490 hours on these activities led to cost savings of $211,000. The overall "manual activity ratio" of the process was assessed to be 38%, while 63% of all activities were performed by automated systems. Figure 21 (bottom) shows charts that display automation rate and cost over time. While the automation rate has increased from 4% to 86% over the period of 12 months, the "cost per purchase order" has decreased from $2.38 to $1.43 per order.

This type of presentation is obviously designed to convince organizations that automation is inevitable. As such, it helps to sell Celonis' process and workflow automation solutions, which are described in the next section. Several example applications for process mining examined in section 2 and 3 also assess automation rates. Figure 2 (left) in section 2.4, for example, shows a comparison of automation rates between two offices of an insurance firm.

6.2 Automating processes, workflows and work activities

Celonis offers a wide range of functionality for process and workflow automation, which can plug into the company's process mining and "execution management" systems[229] and evaluates data on particular process activities in order to automatically initiate other activities, which are referred to as **actions**, either on the Celonis platform or via other enterprise systems.[230] In 2020, Celonis acquired the Czech automation platform Integromat,[231] which is now the basis for Celonis' process and workflow automation technology.[232] The company promises to "integrate real-time process intelligence with targeted action" into "1000+ systems and tools".[233]

Automating workflows across enterprise systems. The Celonis system may, for example, initiate an activity in a company's SAP system when certain conditions are met in the process data. As laid out in the software documentation, it may, for example, automatically detect invoices for which payment is overdue. As overdue payments should result in a delayed delivery date, the system can automatically trigger a change in the sales order stored in the SAP system.[234]

As shown in figure 22 (top center), Celonis visualizes such sequences of automated actions, which it refers to as **action flows**,[235] in the form of icons that describe each action and involved system. In this example, the Celonis system (on the left) first performs a database query in the process data. When certain conditions are met, it initiates a change of the sales order in the SAP system (on the right). Such an action flow may also, for example, result in sending a message via Microsoft Teams or initiating a workflow in other enterprise systems such as ServiceNow, as shown in figure 22 (top right). Action flows consist of "multiple events, decision points and alternative routes" and can "involve an arbitrary number of different applications".[236]

Action flows across multiple systems and automated task assignment. Figure 22 (bottom) shows an action flow that involves a larger number of steps, conditions and systems, including the automated assignment of tasks to

[229] See sections 2 and 3.3.
[230] https://docs.celonis.com/en/automation.html, https://docs.celonis.com/en/setting-up-action-flows-in-studio.html [26.6.2023]
[231] https://www.celonis.com/de/company/ [26.6.2023]
[232] https://www.celonis.com/press/celonis-launches-new-execution-management-innovations-to-eliminate-billions-in-corporate-inefficiencies [26.6.2023]
[233] https://docs.celonis.com/en/automation.html [26.6.2023]
[234] https://docs.celonis.com/en/change-data-in-sap.html [26.6.2023]
[235] https://docs.celonis.com/en/setting-up-action-flows-in-studio.html [26.6.2023]
[236] https://docs.celonis.com/en/setting-up-action-flows-in-studio.html [26.6.2023]

employees. In this example, the Celonis system is used to analyze data on about 1.1 million invoices in a company's debt collection process.[237] Figure 22 (left) shows the process graph. The system identified a list of "top inefficiencies" in the process, which includes 100,000 underpayments and 490,000 late payments.

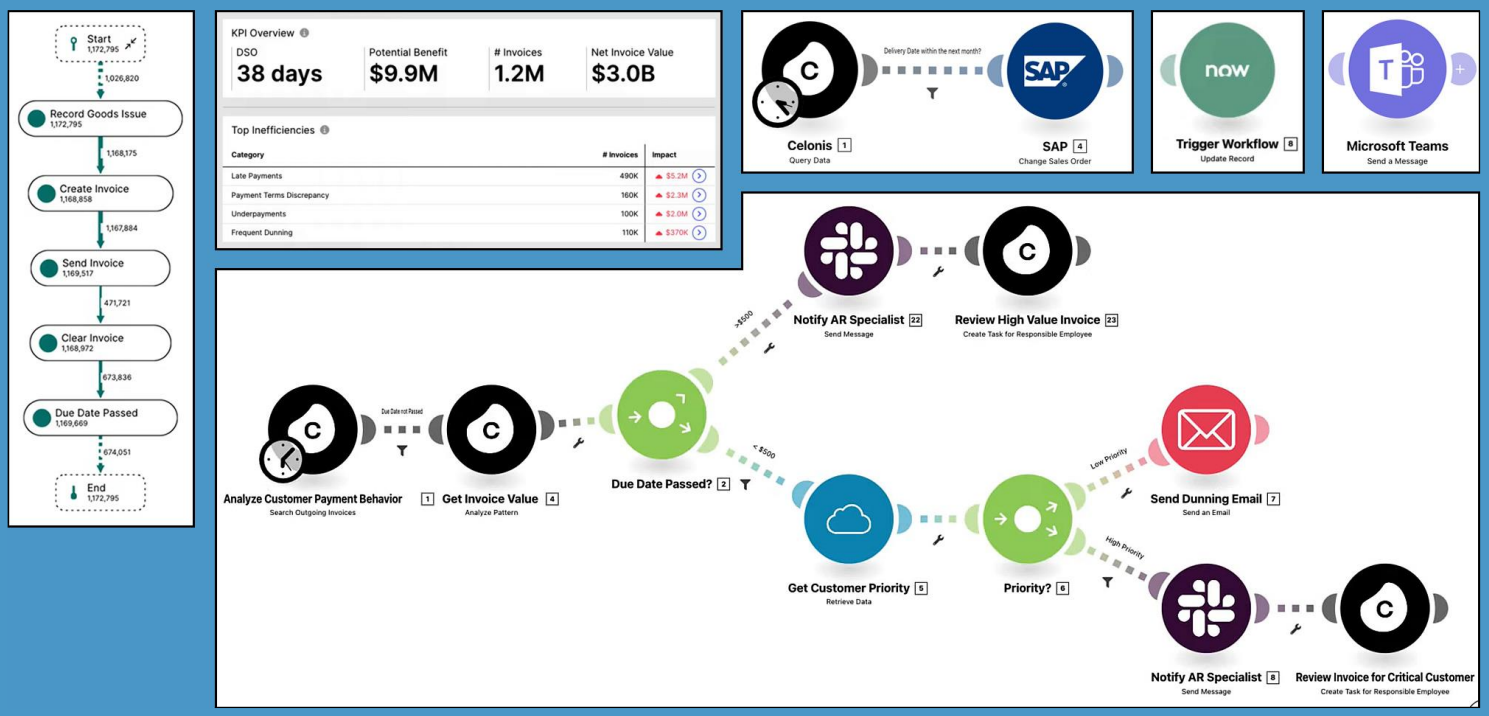

Figure 22: Automating workflows across Celonis and other enterprise systems via "action flows" (Celonis)[238]

To handle late payments, the action flow in figure 22 (bottom) retrieves data on invoices whose due date has passed from the process data stored in the Celonis system. For invoices with an amount lower than $500 it retrieves information about the customer's "priority" from the enterprise CRM system Salesforce. While low-priority customers then automatically receive a dunning email, invoices from "critical" customers are to be reviewed by a customer services representative. For this purpose, the action flow automatically assigns a task to a particular employee in the Celonis system and notifies them by sending a message via the company's Slack communication system. Invoices with an amount greater than $500 are always reviewed by an employee and also result in task assignments.

This example shows how Celonis technology can be used to automate a workflow, which is triggered based on process mining data, involves retrieving data from another enterprise system and results in automated actions including sending messages via email, assigning tasks to employees and notifying them via Slack. As such, the system processes personal data on employees in order to **make decisions** about them and **assign work tasks** to them.

[237] https://www.youtube.com/watch?v=d3a00xOdc0g [26.6.2023]

[238] Figures © Celonis. The figures serve as basis for the discussion of the corporate practices examined in this study. Sources: Demo | Minimize Late Payments in Accounts Receivable, Celonis YouTube channel, 11.7.2022, min 1:45 and 2:18, https://www.youtube.com/watch?v=d3a00xOdc0g; top right: https://docs.celonis.com/en/change-data-in-sap.html; min 2:29: https://www.youtube.com/watch?v=0LCeJ5cf0Ss; https://docs.celonis.com/en/trigger-machine-learning-script.html [23.6.2023]

Figure 23 (top left) shows another action flow that uses Celonis functionality to "find the right assignee" for a task, i.e. to assign a task to a specific employee, based on specified rules and certain criteria.[239] Subsequently, the system proceeds to the action "find the assignee on Slack", which retrieves the employee's email address, and then sends a message to the employee via the company's Slack communication system.[240] Figure 23 (bottom left) illustrates an action flow that involves changing a record in an Oracle database and assigning a task to an employee. Automated task assignment is further discussed in section 6.4.

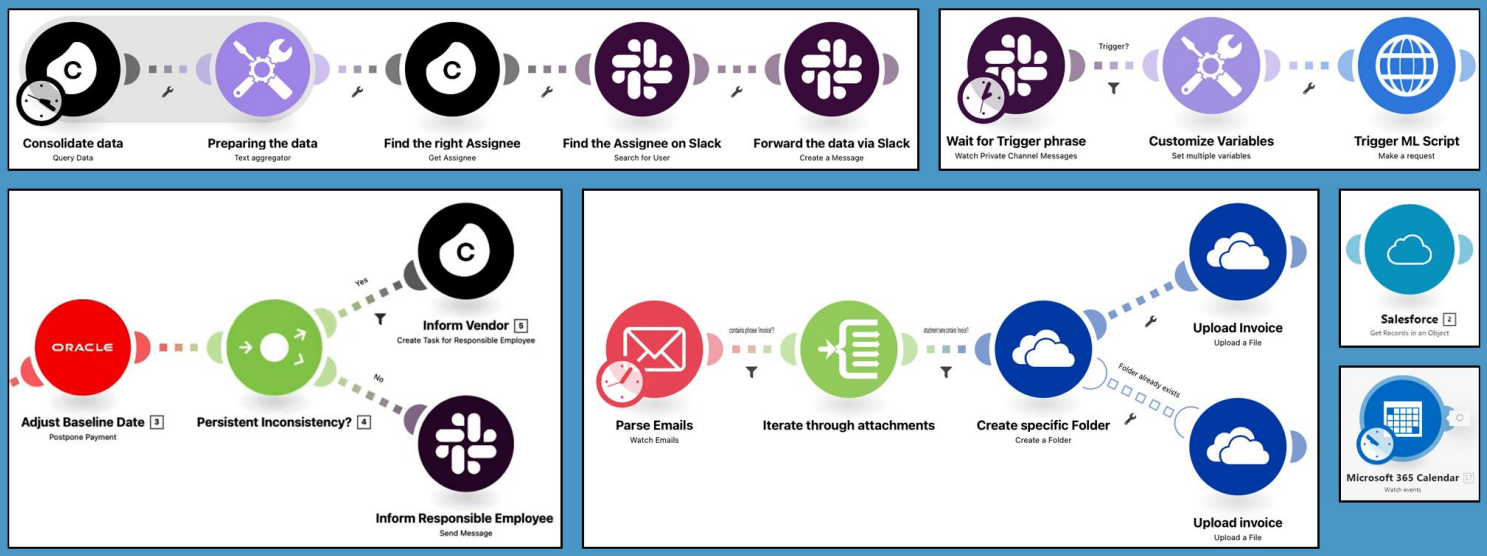

Figure 23: Automating workflows across Celonis and other enterprise systems via "action flows" (Celonis)[241]

Watching chat messages, email communication and calendar events. Action flows can be triggered not only through incidents detected in the process mining data, but also through activities that occur in other enterprise software systems. For example, the automation system can "watch private channel messages" in Slack, "wait for a trigger phrase" and then automatically initiate a particular action, such as triggering a "machine learning script" for analysis purposes,[242] as indicated by figure 23 (top right). This means it can trigger certain activities based on continuous access to chat messages in a corporate communication system, which clearly involves processing personal data on employees. Subsequently, the output of the "machine learning script" may then trigger sending a response message in Slack.[243]

Figure 23 (bottom center) shows another action flow that "watches" an employee's email account in order to extract file attachments and upload them to Microsoft's collaboration system SharePoint.[244] Action flows can also, for

[239] https://docs.celonis.com/en/get-assignee.html, https://docs.celonis.com/en/assignment-rules.html [26.6.2023]
[240] https://docs.celonis.com/en/route-data-to-employee.html [26.6.2023]
[241] Figures © Celonis. The figures serve as basis for the discussion of the corporate practices examined in this study. Sources: https://docs.celonis.com/en/route-data-to-employee.html; https://docs.celonis.com/en/trigger-machine-learning-script.html; min 2:29: https://www.youtube.com/watch?v=0LCeJ5cf0Ss; https://docs.celonis.com/en/archive-invoice-attachments-in-emails-to-sharepoint.html; https://docs.celonis.com/en/setting-up-action-flows-in-studio.html; https://docs.celonis.com/en/microsoft-365-calendar--legacy---action-flow-.html [22.6.2023]
[242] https://docs.celonis.com/en/trigger-machine-learning-script.html [26.6.2023]
[243] https://docs.celonis.com/en/trigger-an-action-flow-from-ml-workbench.html [26.6.2023]
[244] https://docs.celonis.com/en/archive-invoice-attachments-in-emails-to-sharepoint.html [26.6.2023]

example, "watch" events in the Microsoft 365 calendar or access data from a wide range of other enterprise software systems such as Salesforce (figure 23, bottom right), which is detailed in the next section.

Automating workflows across SAP, Microsoft 365 and other enterprise systems. Celonis provides a number of pre-built action flow templates[245] and a wide range of integrations with cloud-based enterprise systems (e.g. SAP, Oracle, Microsoft 365, Salesforce, ServiceNow, Jira, Workday, Google Sheets/Docs/Calendar/Drive, Gmail, Slack, Zoom, Dropbox, Amazon AWS, Automation Anywhere) and other technologies that help to connect action flows to third-party systems (e.g. email, HTTP, FTP, CSV, XML, MySQL, PostgreSQL).[246] Celonis' integration with the major ERP system SAP, for example, enables Celonis to automatically interact with many different SAP functions[247] that may modify or retrieve SAP data and initiate a sequence of yet other activities across the organization.

Workflow automation vs. "robotic process automation" (RPA). Celonis focuses on the automation of processes and workflows by creating direct connections between enterprise software systems via "application programming interfaces" (APIs)[248] and other forms of networked communication between computer programs.[249] But it can also connect to systems for "robotic process automation" (RPA) that try to automate the use of older programs without APIs, based on interacting with graphical user interfaces for human employees (Alpers et al., 2019). RPA has been described as being like "the Windows macro recorder on steroids" (Ruecker, 2021). Celonis' action flows can, for example, take control of programs via Automation Anywhere,[250] a leading RPA vendor.[251] Celonis presents its own automation technology as a solution superior to RPA,[252] but also promotes process mining as a basis for the implementation of RPA initiatives.[253]

Celonis' process and workflow automation technology can also be part of "execution applications" that combine process analysis, optimization and management (see section 3.3). The example application examined in section 4.2, for example, suggests triggering automated actions based on what call center agents say in customer conversations.

6.3 Activity and personal data flows across enterprise systems

Celonis' process and workflow automation technology, as detailed in the previous section, provides a wide range of integrations with enterprise software from other vendors that enable the transmission of data across Celonis and other systems in both directions, including personal data about employees. The company emphasizes that "automations" can be created "in seconds" and, based on its "pre-built connectors and intuitive low-code interface", they are always just "a few clicks away".[254] As soon as an automation that involves a connection to one or multiple third-party systems out of a list of "over 1,000 applications"[255] is established, personal data may continuously flow across Celonis and other involved systems on an ongoing basis.

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[245] https://docs.celonis.com/en/action-flow-templates.html [26.6.2023]
[246] https://docs.celonis.com/en/third-party-apps.html, https://docs.celonis.com/en/actions.html [26.6.2023]
[247] https://docs.celonis.com/en/sap-actions.html [26.6.2023]
[248] See e.g. https://en.wikipedia.org/wiki/API
[249] https://docs.celonis.com/en/security-details-for-action-flows-and-third-party-applications.html [26.6.2023]
[250] https://docs.celonis.com/en/automation-anywhere--action-flow-.html [26.6.2023]
[251] Forrester (2023): The Forrester Wave: Robotic Process Automation, Q1 2023. Forrester, February 28th, 2023.
[252] https://www.celonis.com/solutions/initiatives/rpa-automation/ [28.6.2023]
[253] See e.g. https://www.celonis.com/blog/securing-rpa-through-process-mining/ [28.6.2023]
[254] https://www.celonis.com/ems/targeted-action/ [28.6.2023]
[255] Ibid.

Monitoring and sending messages in Microsoft Teams. The integration with Microsoft Teams, for example, enables the Celonis system to automatically "monitor" and "watch" messages and replies in team messages, channel messages and other chats.[256] The Celonis system can also send and reply to messages and make use of almost any other functionality available in Teams. This includes creating, updating and deleting online meetings, channels and team members, accessing information about them and searching for users. In theory, access to data and functionality is protected by Microsoft Teams' permission system.[257] Organizations who want to include Teams in action flows or other automation apps will, however, grant Celonis permission to access the required data and functionality.

Access to Gmail and Microsoft 365 Email. The Celonis system can also access the email inbox of an employee, if an automation app requires access. As figure 24 (left) shows, it can, for example, "watch" incoming emails, search for emails, mark them as read or send an email using an employee's "company" or "personal" Gmail account.[258]

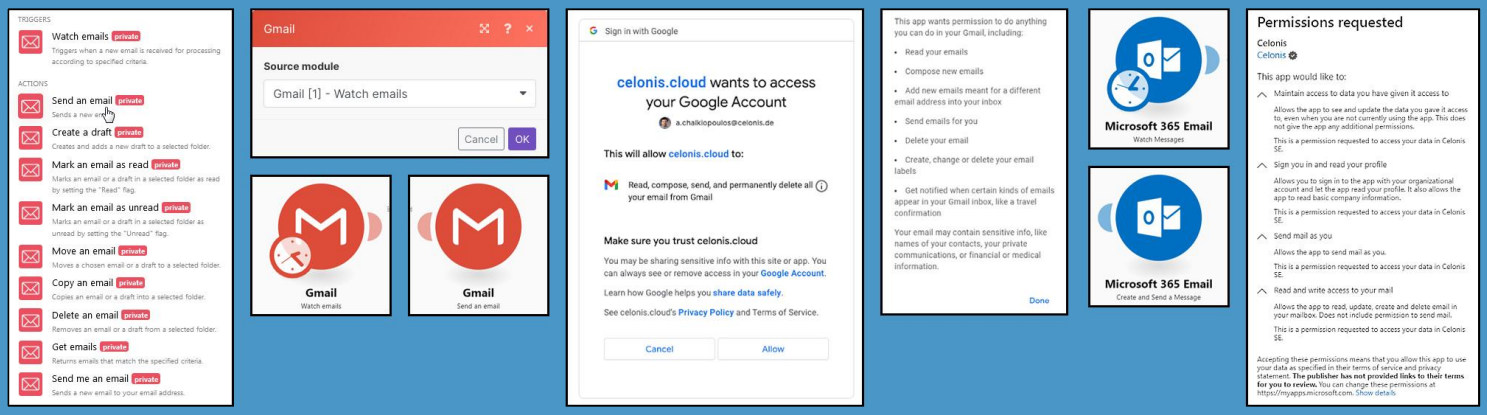

Figure 24: Accessing employees' Gmail and Microsoft 365 email accounts (Celonis)[259]

When an employer builds an automation app that aims to watch incoming emails in order to automatically initiate some activity in the Celonis system, Google will display a popup window to the employee asking for access to their Google account. As shown in figure 24 (center), confirming this request may allow the Celonis system to "read, compose, send, and permanently delete all your email from Gmail" or simply "do anything you can do in your Gmail".[260] Similarly, when an automation app requires watching or sending messages in an employee's Microsoft 365 email account, they need to confirm Celonis' request for "read and write access" or other permissions,[261] as shown in figure 24 (right). Even if the corresponding automation app initially provides non-nefarious or beneficial functionality, the Celonis system may have gained permanent access to the employee's email account.

[256] https://docs.celonis.com/en/microsoft-teams--action-flow-.html [28.6.2023]

[257] Ibid.

[258] https://docs.celonis.com/en/gmail--action-flow-.html, https://docs.celonis.com/en/apps---permissions.html [28.6.2023]

[259] Figures © Celonis. The figures serve as basis for the discussion of the corporate practices examined in this study. Sources: https://docs.celonis.com/en/apps---permissions.html, https://docs.celonis.com/en/gmail--action-flow-.html, https://docs.celonis.com/en/email--action-flow-.html; Gmail and Microsoft 365 Email icons from: https://www.make.com/en/templates/1617-automatically-forward-new-gmail-emails-containing-a-specific-word-to-another-email-address, https://www.make.com/en/templates/2921-create-a-new-action-in-focuster-when-a-new-office-365-e-mail-is-received-and-meets-specified-criteria, https://www.make.com/en/templates/2564-send-an-email-via-office-365-email-when-a-survey-is-submitted [28.6.2023]

[260] https://docs.celonis.com/en/email--action-flow-.html, https://docs.celonis.com/en/apps---permissions.html [28.6.2023]

[261] https://docs.celonis.com/en/microsoft-365-email--action-flow-.html, https://docs.celonis.com/en/apps---permissions.html [28.6.2023]

In the same way, Celonis' automation technology can access data and functionality from many other enterprise software systems or, in turn, provide data and functionality to other systems. This includes ERP and CRM software, task management systems and cloud-based services from vendors such as SAP, Oracle, Microsoft, Salesforce, ServiceNow, Jira, Workday and Google.[262]

The "Make" integration platform. Celonis' process and workflow automation functionality is based on technology from Integromat, a company it acquired in 2020.[263] Integromat has since then been rebranded as "Make" and still exists as a standalone service.[264] According to the company, Make is a "no-code integration tool" and a "platform" that can be used for everything from "building e-commerce apps" to "automating entire end-to-end business processes" without "writing any code".[265] It lets organizations "visually create, build, and automate workflows"[266] across hundreds of third-party applications and APIs.[267] The Make platform uses the same visual mechanisms and icons as Celonis' "action flow" technology, as detailed in the previous section.

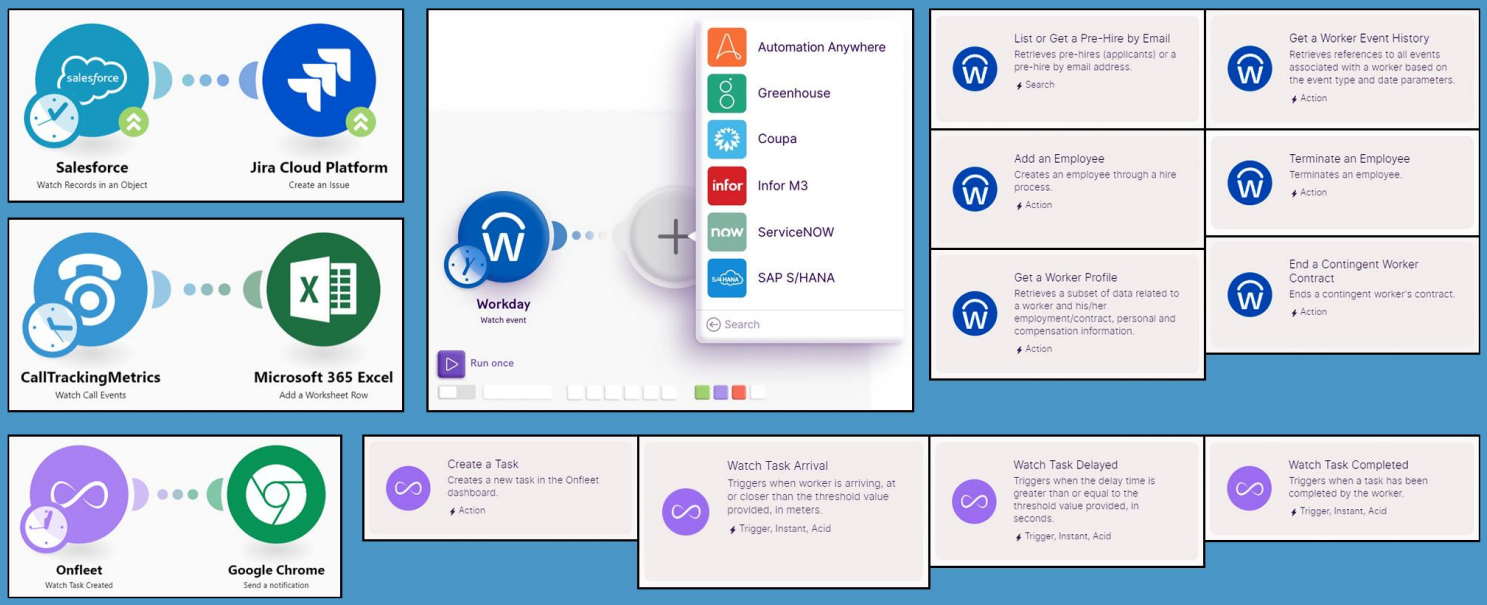

Figure 25: Automating workflows across enterprise systems via Celonis' Make platform (Make/Celonis)[268]

Figure 25 illustrates how the Make platform can be used to set up automated workflows across systems. For example, it can automatically **create tasks** in the issue tracking system Jira[269] when new records are created in the CRM

[262] https://docs.celonis.com/en/third-party-apps.html, https://docs.celonis.com/en/actions.html [26.6.2023]
[263] See previous section.
[264] https://www.make.com/en/integromat-evolves-to-make [1.7.2023]
[265] Ibid.
[266] https://www.make.com/en [1.7.2023]
[267] https://www.make.com/en/product-description.pdf [1.7.2023]
[268] Figures © Make/Celonis. The figures serve as basis for the discussion of the corporate practices examined in this study. Sources: https://www.make.com/en/templates/6752-create-jira-issues-from-new-records-in-salesforce, https://www.make.com/en/templates/8469-add-microsoft-365-excel-worksheet-rows-for-new-calltrackingmetrics-calls, https://www.make.com/en/enterprise, https://www.make.com/en/integrations/workday-hcm, https://www.make.com/en/templates/5986-get-google-chrome-notifications-for-created-task-on-onfleet, https://www.make.com/en/integrations/onfleet [1.7.2023]
[269] https://www.atlassian.com/software/jira/guides/issues/overview [1.7.2023]

system Salesforce (figure 25, top left).[270] It can also automatically add a new row in an Excel spreadsheet when a call center agent receives a phone call as detected by a **call tracking system** (figure 25, left vertical center).[271]

Figure 25 (top center) shows how the platform can connect the **human resource system Workday** with other enterprise systems such as SAP and Infor. As a part of the pre-build integration,[272] other enterprise systems can automatically access 48 functions and mechanisms provided by Workday. This includes retrieving information about job applicants, adding a new employee record, retrieving a "worker profile" and even terminating an employee or a "contingent worker contract" (figure 25, top right).[273] As such, any software, such as a task management system, could automatically retrieve personnel records from the Workday HR system or even trigger a termination.

Figure 25 (bottom) shows another example of a pre-built integration that allows access to 20 functions and mechanisms provided by Onfleet,[274] a system that manages **delivery workers**.[275] Using this integration, other enterprise applications can automatically create, modify and "watch" delivery tasks in the Onfleet system. Other systems could, for example, be informed when a driver's location has been tracked to be close to the place of delivery, when a driver is late or when their delivery is completed (figure 25, bottom right), and then automatically initiate other activities.

A system like the Make platform or Celonis' automation technology based on "action flows" is sometimes referred to as an **"Integration Platform as a Service" (IPaaS)**. The consulting firm Gartner defines IPaaS systems as "suite[s] of cloud services enabling development, execution and governance of integration flows connecting any combination of on premises and cloud-based processes, services, applications and data within individual or across multiple organizations".[276] Using the Make Platform or Celonis' process and workflow technology, managers or business analysts can quickly expand functionality and data flows across different enterprise software systems, which can include the transmission of personal data and automated decision-making about employees.

6.4 Automating task assignment and algorithmic management

The Celonis system can turn into a comprehensive **task management system** that automatically assigns tasks to employees when certain criteria are met in the process data or certain activities occur in other enterprise software systems. The task assignment functionality is based on the company's automation technology. As detailed in section 6.2, the Celonis system can automate workflows by detecting certain incidents that initiate sequences of actions, which can include the automated assignment of tasks to employees, who see their assigned tasks in a list.

Section 6.2 summarizes an example of an automated workflow that detects late payments in a company's debt collection process and decides whether the customer receives an automated payment reminder or warrants a human review, the latter of which results in the assignment of a review task to an employee. Figure 26 (left) shows how workers see these review tasks in the Celonis system. The example screen displays a list of 50 open review tasks assigned to an employee named "Robert Clark". For a particular late payment incident, which is assessed as "urgent", the system "suggests" to "escalate" the case by calling the customer, as shown in figure 26 (center). To take

[270] https://www.make.com/en/templates/6752-create-jira-issues-from-new-records-in-salesforce [1.7.2023]
[271] https://www.make.com/en/templates/8469-add-microsoft-365-excel-worksheet-rows-for-new-calltrackingmetrics-calls [1.7.2023]
[272] https://www.make.com/en/help/app/workday-human-capital-management [1.7.2023]
[273] https://www.make.com/en/integrations/workday-hcm [1.7.2023]
[274] https://www.make.com/en/integrations/onfleet [1.7.2023]
[275] https://onfleet.com/ [1.7.2023]
[276] https://www.gartner.com/en/information-technology/glossary/information-platform-as-a-service-ipaas [1.7.2023]

action, the employee can, however, choose from three different options, which are displayed in the form of buttons. They can either call the customer, send a payment reminder email or request internal support.

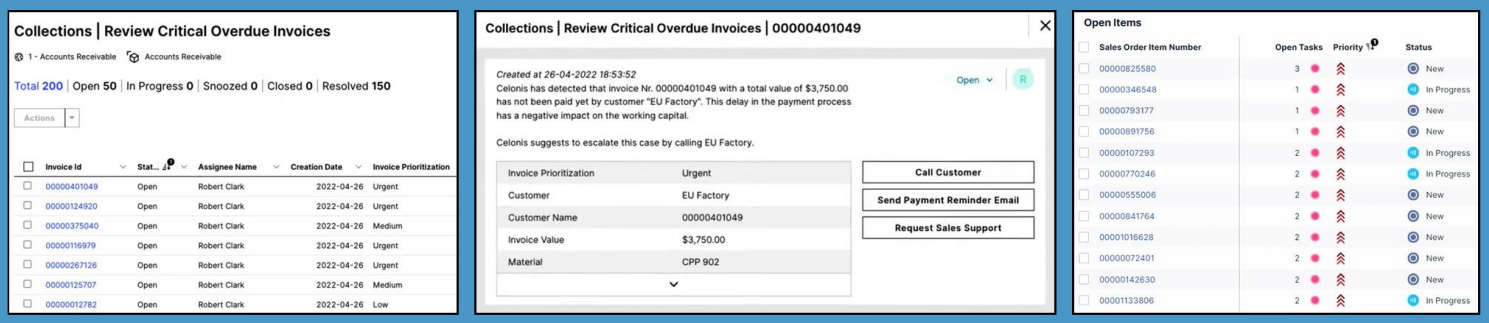

Figure 26: Automated task assignment and recommendations for employees (Celonis)[277]

Celonis offers several software modules that include functionality for automating task assignment, including the "action engine",[278] which is a "rather old product that will get replaced by the task inbox at some point in time", according to a Celonis representative.[279] The "task inbox" in the Celonis system "acts as the central location" from which employees "manage and complete the tasks assigned to them".[280] In addition, employers or third-party vendors can integrate custom task management mechanisms[281] into their "execution applications", which combine functionality for the analysis, optimization, automation and management of particular processes such as insurance claim handling, warehouse management or manufacturing (see section 3.3). Celonis also offers to assign tasks to managers who are responsible for managing and optimizing a particular process by meeting certain KPI objectives and targets (see section 3.1).

Automated task assignment. The creation and assignment of a task can result from almost any kind of incident that is detected by the system based on predefined rules and mechanisms.[282] For example, the detection of an overdue invoice for a customer that is considered important with an amount greater than $500 may lead to the assignment of a task for a customer service representative, who should review the invoice and call the customer. Tasks could also result from insurance claims, warehouse items, manufacturing units or call center conversations, which show certain characteristics such as being handled too slowly, going through an undesired process step or just requiring an action performed by an employee before proceeding to the next step. Usually, these tasks refer to a particular "case", such as a particular insurance claim or sales order. Figure 26 (right) shows an example of a list of tasks assigned to an employee, each of which refers to a sales order. The task list is sorted by priority and also displays status information about whether a task is "new" or "in progress". Some sales orders have more than one "open" task attached.

[277] Figures © Celonis. The figures serve as basis for the discussion of the corporate practices examined in this study. Sources: Demo | Minimize Late Payments in Accounts Receivable, Celonis YouTube channel, 11.7.2022, min 3:32 and 3:40, https://www.youtube.com/watch?v=d3a00xOdc0g; Celonis Shipped Not Invoiced App | Demo, Celonis YouTube channel, 23.1.2023, min 1:10, https://www.youtube.com/watch?v=sK8fYoOmKTg [28.6.2023]

[278] https://docs.celonis.com/en/action-engine.html [29.6.2023]

[279] https://www.celopeers.com/s/question/0D50700001X3COTCA3/what-is-the-difference-between-action-engine-and-action-flows [29.6.2023]

[280] https://docs.celonis.com/en/introduction-to-the-inbox.html [29.6.2023]

[281] https://docs.celonis.com/en/involve-business-users-with-tasks.html [29.6.2023]

[282] Ibid.

With the help of Celonis' process and workflow automation functionality, as described in section 6.2, tasks can also result from activities in enterprise software systems whose activity data is not part of the process mining data. Particular incidents that occur, for example, in SAP, Salesforce or Microsoft 365 may trigger an action flow, which then leads to the assignment of a task to an employee in the Celonis system. As such, a task could result from incidents as diverse as an incoming email that contains a certain phrase, information about an anomaly in a production line detected by a manufacturing system or information about the fact that a field service worker has arrived at a customer site, according to data recorded by Salesforce. Tasks can be dynamically assigned to particular employees according to specified rules and criteria.[283]

Comprehensive task management. Figure 27 demonstrates how a Celonis application can turn into a fully-fledged task management system for customer service representatives. While figure 27 (left and center) shows the "team lead view" for managers, which displays extensive information about tasks assigned to named workers and which can be filtered by employee, figure 27 (right) shows the task list as shown to a particular service representative.

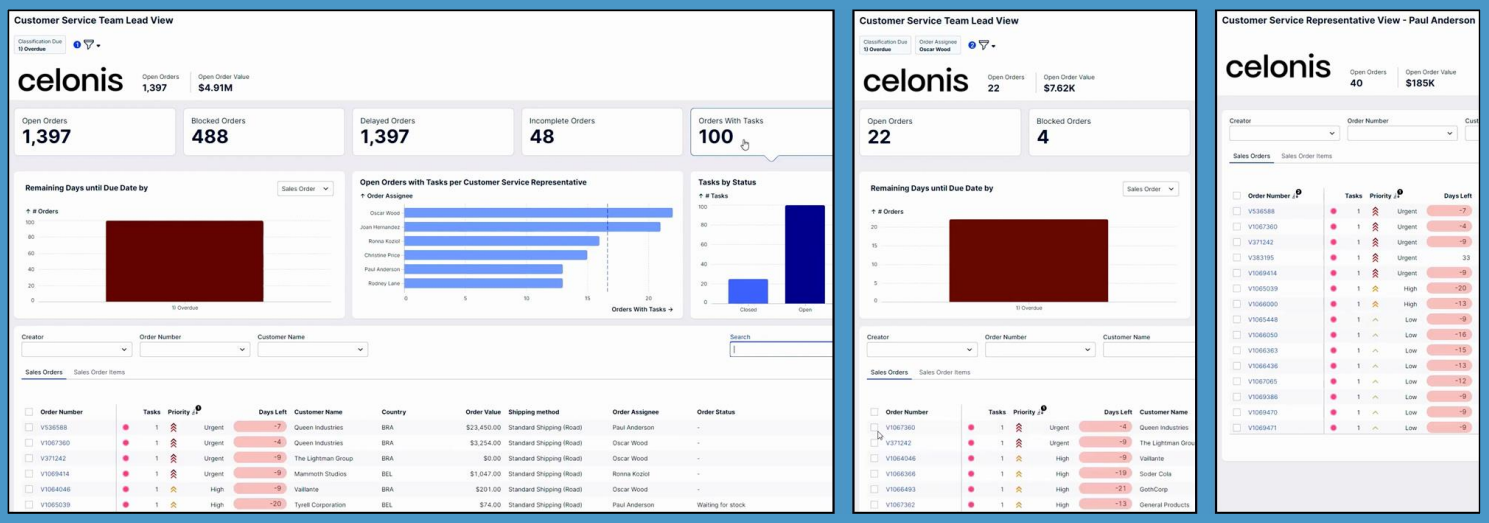

Figure 27: Task management for "team leads" and "customer service representatives" (Celonis)[284]

While the software documentation always uses the notion of "tasks" that get "assigned" to employees in order to be "completed" or "resolved",[285] Celonis sometimes also refers to "intelligent recommendations" and "so-called tasks".[286] According to the company, tasks are a "call to action (or at least a notification)" for a specific employee. Tasks "propose" the "next best action" an employee "can take".[287] On its website, Celonis uses the notion of "attended automation", which should "bring a human-in-the-loop" (sic). The system can "prioritize tasks that will drive the biggest business impact" and "share prioritized tasks either in Celonis or in external systems".[288]

[283] https://docs.celonis.com/en/task-augmentation.html, https://docs.celonis.com/en/get-assignee.html [26.6.2023]
[284] Figures © Celonis. The figures serve as basis for the discussion of the corporate practices examined in this study. Source: Celonis Open Order Processing App | Demo, Celonis YouTube channel, 23.1.2023, min 2:25, 2:44, 3:01, https://www.youtube.com/watch?v=rQgmSl9A440 [28.6.2023]
[285] https://docs.celonis.com/en/introduction-to-the-inbox.html, https://docs.celonis.com/en/inbox-navigation.html, https://docs.celonis.com/en/involve-business-users-with-tasks.html, https://docs.celonis.com/en/tasks---alerts.html, https://docs.celonis.com/en/assignment-rules.html [30.6.2023]
[286] https://docs.celonis.com/en/skills-and-automation.html [30.6.2023]
[287] https://docs.celonis.com/en/task-configuration.html [30.6.2023]
[288] https://www.celonis.com/ems/targeted-action/ [30.6.2023]

Tasks, recommended actions and alerts. Celonis' task management system can automatically prioritize tasks and assign them to particular employees, who see their tasks either in their "task inbox" or in an "execution application". These tasks can contain one or several options for recommended actions,[289] as shown in figure 26 (center). For tasks that are automatically assigned to employees, they cannot manually set the task to the status "resolved", but must perform one of the recommended actions. The task's status will automatically change to the status "resolved" when the mechanism that initiated the creation of the task detects that the issue has been resolved.[290] The same mechanisms that detect incidents and lead to the automated creation of tasks can also lead to the creation of "alerts".[291] Alerts are visually highlighted in the user interface and can be configured to lead to additional actions, such as email notifications. The system provides access to a log that lists incidents, tasks, alerts and information about whether they were resolved.[292]

Of course, automated task assignment relies on extensive processing of personal data about employees, including "automated individual decision-making" as defined in the GDPR.[293]

[289] https://docs.celonis.com/en/involve-business-users-with-tasks.html [30.6.2023]
[290] https://docs.celonis.com/en/task-augmentation.html, https://docs.celonis.com/en/inbox-navigation.html [30.6.2023]
[291] https://docs.celonis.com/en/create-alerts.html [30.6.2023]
[292] https://docs.celonis.com/en/involve-business-users-with-tasks.html [30.6.2023]
[293] Article 22 GDPR

7. Summary of data practices that affect workers and concluding remarks

Any organization will aim to manage and improve its operational processes, procedures, workflows and consequently how work is performed. Celonis' technology for process analysis and workflow automation can certainly be used for legitimate purposes that benefit both the organization and workers. This investigation about software systems provided by Celonis, however, focuses on the potential ramifications for workers. It shows that employers can use these technologies to exploit comprehensive personal data about work activities and behaviors in the workplace in order to reorganize and streamline work according to their business goals, irrespective of whether they target individual workers, teams or other groups. More specifically, organizations can utilize these systems to expand control over workers, subject them to extensive digital monitoring and make automated decisions about them. Many of the data practices examined in this case study are usually discussed under the buzzword "AI".

This section summarizes mechanisms and data practices identified in this investigation and reflects on the findings.

7.1 Mechanisms, data practices and potential implications for workers

Celonis' technology for the analysis, optimization and management of operational processes, as examined in sections 2, 3, 4 and 6, relies on time-stamped activity and event log data recorded by different software across an organization. It creates a digital representation of every work activity and step that occurs when handling a "case", such as an insurance claim, loan application, customer order, manufacturing unit or warehouse item, based on real-time data flows from enterprise software systems, such as for ERP, CRM, HRM, manufacturing, task management or communication. The amount of activity records processed by the Celonis system can be large. As table 1 shows, it may **track data about work activities** related to several hundred thousand or even a million process cases.

Process "cases"	Examples of tracked work activities and steps	Activity records include employee information?
143,000 insurance claims (section 2.1)	Created claim file, verified insurance coverage, scanned evaluation report, approved repair, updated claim record, booked invoice from repair shop	Unknown
22,000 warehouse items (section 2.5)	Started picking item, completed picking, started put on conveyer, completed put on conveyer, started loading, completed loading	Unknown
350,000 service desk requests (section 2.6)	Ticket filed, changed category, changed priority, assigned, in progress, reassigned to another service center, resolved, closed	Unknown
194,000 customer calls (section 4.2)	Started call, greeted caller, authenticated caller, determined reason for call, gathered information, issue resolved, offered credit card, offered survey, ended call	Yes
10,000 manufacturing units (section 4.3)	Started painting, hung parts, applied hand spray, applied paint, applied paint oven, offloaded unit	Yes
8,000 creative projects (section 4.4)	Started project, completed copywriting, completed proofreading, suggested edits, completed design, uploaded final files, delivered print, finished project	Yes
1,590,000 purchase orders (section 4.7)	Created purchase order, validated order, rejected order, released order, sent order, recorded goods receipt, recorded invoice receipt, cleared invoice	Yes
Timecards from 20,000 employees submitted to HR (section 4.6)	Created timecard, submitted timecard, corrected timecard, approved timecard, created receipt, detected missing timecard	Yes

Table 1: Examples of cases, work activities and steps analyzed by Celonis' process mining system

Each activity record processed by Celonis typically contains information about the type of activity performed, a

timestamp that reflects the time it was performed and information on the subject or object of the activity, for example, a particular insurance claim, customer call or warehouse item. In addition, it may contain information about the employee who performed the activity.

In relation to personal data about employees, Celonis' process mining system can be used in three different ways:[294]

(a) **Activity records do not contain personal data about the employees who performed the activity**. As such, any analysis based on these activity records will contain aggregate information only.
(b) **Activity records contain personal data about the employees who performed the activity**, but the analysis results contain only aggregate information and do not expose personal data about employees.
(c) **Both activity records and analysis results contain personal data about employees**. The latter may involve anything from reports that display some information about individual workers to granular performance monitoring and control at the individual level.

While Celonis' process mining technology can (a) be used without analyzing or processing any personal data about employees, the software documentation and many examples suggest that (b) activity records commonly contain personal data about the employees who performed the activity.[295] As the investigation shows, (c) exposing personal data about employees in the analysis output also appears to be a common way of using the Celonis system.[296]

Table 2 shows a summary of mechanisms and data practices identified in this investigation. While the left column includes mechanisms that (b) rely on extensive personal data processing, but do not expose or utilize it in their output, the right column summarizes mechanisms that (c) expose personal data about individual workers in their output, single them out or act on them, for example, by making decisions about employees.

(1) Process analysis and optimization. As detailed in table 2 (1) (c), Celonis technology for process analysis and optimization may display information about employees and the tasks performed by them at the individual level in analysis results and reports. Where this occurs for legitimate purposes, for example, to organize work or identify workload misallocation, skill mismatches or training needs, it may still be prone to misuse for other purposes.[297]

Exposing personal data about workers in the output of the analysis may also occur in ways that can be considered disproportionate or intrusive. As this investigation shows, analysis results and reports routinely display metrics about employees' speed of work, work outcomes and behaviors at the individual level. The system can be used to analyze processes, work activities and metrics for individual employees, compare analysis results between individuals and rank them by a wide range of metrics. It can be used for granular performance and behavior monitoring, from assessing task performance down to the second in manufacturing to rating what call center agents say in customer conversations.

Putting workers under pressure through digital monitoring and control **at the individual level** can have a wide range of negative effects on workers, their rights and well-being and the work they carry out (see e.g. King, 2020, Christl, 2023; O'Brady and Doellgast, 2021; Baiocco et al., 2022).

[294] This list ignores possible edge cases, such as the indirect identification of employees through case, activity and group information.
[295] See sections 2.7 and generally sections 2, 3, 4, 6
[296] See section 4
[297] See e.g. sections 4.3 and 4.4

Celonis functionality/module	(b) Mechanisms that rely on extensive personal data processing about work activities and workers, but do not expose or utilize personal data in their output	(c) Mechanisms that expose personal data about workers in their output, single out workers at the individual level or act on them, e.g. by making decisions about them
(1) Process analysis and optimization Celonis "process mining" technology (sections 2, 3, 4, 6)	• Ingest extensive personal data about processes and work activities from enterprise systems (section 2.1) • Analyze processes and work activities (section 2) • Document processes, extract knowledge about processes and work activities (section 2.2) • Standardize processes and workflows (section 2.2) • Detect and eliminate inefficiencies such as "process violations" and "undesired activities" (section 2.4) • Streamline, accelerate or reorganize processes by optimizing them towards business goals, e.g. increased productivity, increased efficiency, lower costs, higher customer satisfaction (section 2.2) • Monitor processes, work activities and metrics on an ongoing basis (section 2.2) • Analyze and "filter" data on processes, work activities and metrics at the level of groups, e.g. teams, departments, offices, subcontractors (section 2.3, 2.6) • Compare process data between groups (section 2.3) • Assess work activities, characteristics, performance and behaviors with respect to social collaboration between workers at the group level (section 4.8) • Measure, analyze and assess manual, automated and automatable workflows and activities (section 6.1)	• Display data about individual workers for legitimate purposes in a way that may be disproportionate, intrusive or prone to be misused for other purposes (sections 4.4–4.7) • Analyze and "filter" data on processes, work activities and metrics at the individual level (sections 4.1, 4.2, 4.4–4.7) • Compare process data between workers (sections 4.1, 4.5) • Display individual-level metrics regarding speed of work, performance, outcomes or behaviors (sections 4.1–4.7, 5.2) • Rank workers (sections 4.1–4.6, 5.2) • Granular behavior and performance monitoring, from assessing task performance down to the second to rating behavior in call center conversations (sections 4.2, 4.3) • Assess work activities, performance and behaviors with respect to social collaboration between workers (section 4.8) • Analyze social interactions and collaboration between individual workers (section 4.8) • Use group-level analysis results to monitor the performance of team supervisors and managers (sections 2.3, 2.6, 4.6)
(2) Management automation Celonis "process AI", "process simulation" and "transformation center" functionalities; Celonis-based "execution applications" (sections 2, 3, 6)	• Automate process optimization by suggesting possible "causes" for process inefficiencies (section 2.4) • Automate process management and optimization by outlining the need to meet certain KPI targets or other quantifiable business objectives (section 3.1) • Simulate, forecast and predict the impact of changes to processes and work activities (section 3.2) • Enable employers and third-party vendors to develop Celonis-based applications that combine (1), (2) and (3) in order to automate process analysis, management and work organization (sections 3.1, 6.2)	• Automatically assign tasks or provide recommendations to managers who are responsible for meeting KPI targets or other business objectives
(3) Workflow automation, automated task assignment and system integration Celonis "action flows", its built-in task management system and its "Make" integration/automation platform (section 6)	• Automate workflows and work activities across Celonis and hundreds of enterprise software systems, e.g. ERP, CRM, HRM, task management, communication/collaboration, data warehousing (section 6.2) • Automatically trigger actions across systems when certain conditions are met in Celonis' process data, i.e. apply mechanisms for process analysis to automated workflows in real time (section 6.2) • Quickly expand functionality and personal data processing about workers and work activities across different cloud-based systems and APIs (section 6.3) • Utilize process analysis for the implementation of robotic process automation / RPA (section 6.2)	• Apply mechanisms for process analysis that expose personal data about employees in their output to automated workflows in real time (section 6.2) • Make automated decisions on workers, e.g. task assignment • Automatically assign tasks to workers when certain criteria are met in Celonis' process data or when certain activities occur in other enterprise software systems (section 6.4) • Decide who is assigned a task (section 6.4) • Automatically prioritize tasks or raise alerts (section 6.4) • (Semi)automate employee decision making by automatically providing recommended actions to them (section 6.4)

Table 2: Mechanisms and data practices identified in this investigation

While exposing personal data about employees in the output of the analysis or using the system for granular performance and behavior monitoring can clearly be problematic, Celonis' technology also affects workers even when it doesn't expose personal data in the analysis output.

As table 2 (1) (b) summarizes, the system potentially processes large amounts of personal data about employees and work activities performed by them in order to streamline processes and workflows by optimizing them towards an organization's business goals, such as increased productivity, increased efficiency and lower costs. This can lead to an acceleration and intensification of work, a reduction in staff or to a complete reorganization of how work is carried out and by whom. Celonis helps employers to standardize processes, which can reduce work discretion and facilitate deskilling (Braverman, 1974). The system helps to extract valuable knowledge (Smith, 2001) about organizational processes and work activities, which increases the information and power asymmetry between employers and workers (Andrejevic, 2014; Baiocco et al., 2022). Knowledge extraction, standardization and the ability to streamline and reorganize work can reduce workers' bargaining power, make them easier to replace, facilitate outsourcing and automation and lead to lower wages (Kellogg et al., 2020; Rogers, 2020; Newman, 2016; Bernhardt, 2021; Schildt, 2020; Zuboff, 1988; Baiocco et al., 2022).

Celonis provides a wide range of functionality to analyze data on processes, work activities and metrics **at the group level**, such as teams, departments, branch offices or subcontractors, including reports that compare different groups to each other. Groups whose case handling time, service quality or costs are assessed as unsatisfactory will typically be required to accelerate work, tighten quality control or cut costs. Group-level analyses can be exploited to facilitate internal competition between an organization's units or divisions (Khoja, 2008). They can represent a form of individual-level performance monitoring for team supervisors and managers,[298] who are expected to pass the pressure on to employees. Group-level analyses can also result in "peer control", where workers are "expected to maintain levels of output for themselves and use peer pressure to influence the level of output for their team members" (Townsend, 2005). In addition, Celonis offers the ability to analyze and assess social interactions and collaboration between employees, including their work activities, characteristics, performance and behaviors, both for groups and for individual workers.[299]

(2) Management automation. As summarized in table 2 (2) (b), Celonis provides a number of additional mechanisms that aim to automate process management. While the entire system for process analysis and optimization could be considered a form of management automation, its functionality for automatically suggesting possible "causes" for detected process inefficiencies, which the company refers to as "process intelligence" or "process AI", represents algorithmic management in a narrower sense. Similarly, the "transformation center" module presents goals and objectives to managers, who are responsible for the supervision or reorganization of particular processes and then systematically tracks progress towards KPI targets over time. This can include the automated assignment of tasks and recommended actions to managers. The "process simulation" module helps managers forecast and predict the impact of changes to processes and work activities. These management automation mechanisms can help employers better meet their business objectives, for example, by streamlining work, maximizing workload or reducing costs. They may also help managers justify harsh decisions by referring to purportedly "objective" data.

[298] See table 2 (1) (b) and (1) (c)
[299] Ibid.

In 2020, Celonis started to refer to its software as an "execution management system" (EMS), putting the focus on managing and changing operational processes rather than merely analyzing them. Employers and third parties can create Celonis-based "execution applications", which combine process analysis and optimization with functionality for workflow automation and task management, as described in the following paragraphs. Similar to other cloud-based enterprise software systems, Celonis has turned into a **platform**. Third-party vendors can offer Celonis-based applications via the company's app, "marketplace". This includes, for example, applications to manage or supervise work in manufacturing, warehouses, helpdesk services and call centers.

(3) Workflow automation, automated task assignment and system integration. In recent years, Celonis has started to offer additional functionality for workflow automation, as summarized in table 2 (3) (b), which can plug into its process mining system and automatically initiate actions on the Celonis platform or on other enterprise software systems when certain criteria are met in the process data. The company's workflow automation technology can, for example, trigger the modification of a database record in a company's SAP or Salesforce system when it detects insurance claims, warehouse orders or manufacturing units with certain characteristics according to the process data. It can also send an email via Microsoft 365 when the Celonis system detects a process activity it considers inefficient. It can automatically initiate a particular action, such as terminating an employee, in the HR system Workday. Conversely, Celonis' workflow automation system can also trigger actions based on real-time access to data from other enterprise systems. It can, for example, automatically trigger particular actions when certain criteria are met while "watching" an organization's chat system or an employee's email inbox. It can also initiate particular actions when a worker receives a phone call or when a delivery driver is tracked to be close to their delivery destination.[300]

Both Celonis and its standalone workflow automation and integration platform "Make" can connect hundreds of enterprise software systems to each other, including systems for ERP, CRM, HRM, task management, communication and collaboration, data warehousing and robotic process automation (RPA). These integrations can be set up in a quick and frictionless manner and then enable constant data flows between Celonis and other systems, which may include sharing extensive personal data about employees.

As described in table 2 (3) (c), Celonis workflow automation technology can also make **automated decisions about workers**. Most importantly, it can **automatically assign tasks** to employees when certain criteria are met in the process data or when certain incidents are detected in other enterprise systems. For this purpose, both the Celonis system and Celonis-based applications include comprehensive task management functionality, which can decide which employee should be assigned a particular task and then displays the task to the assignee. These tasks can also include a limited set of recommended actions that can be performed. Celonis can also automatically prioritize tasks, raise alerts and send notifications. To resolve a task, the assignee may have to choose one of the recommended actions or otherwise resolve the conditions that originally triggered the creation of the task. Obviously, these mechanisms for automated task assignment involve extensive personal data processing about employees and represent a form of algorithmic management.

While these mechanisms can certainly be used for legitimate purposes that benefit both the organization and employees, **algorithmic management** poses a wide range of risks for workers, as several authors have discussed (Bai-

[300] See sections 6.2 and 6.3.

occo et al., 2022; Jarrahi et al., 2021; Wood, 2021; Rogers, 2020; Mateescu and Nguyen, 2019). This task management system structures and constrains the ways in which workers can interact with the system, with one another, with the data and with other stakeholders in the process. It potentially divorces work from the reasons for doing a task, which remain opaque (Danaher, 2016), and shifts authority from humans to the information system (Aneesh, 2002). Especially when combined with a limited set of possible actions, this restricts autonomy and discretion at work. It may result in a variety of side effects, such as employees experiencing the algorithmic system as arbitrary rule, employees prioritizing their efforts to match the system's expectations, the invisibility of work activities that lack an accurate digital representation in the system or even complete dysfunctionality (Evans and Kitchin, 2018). Not least, algorithmic management, especially when based on statistical inferences, entails the risk of discrimination against already disadvantaged employees (Todolí-Signes, 2019).

At a more fundamental level, and this applies to Celonis' technology at large, the omnipresence of **quantification and metrics** presents several risks for workers. While metrics are often claimed to be "neutral", "objective" and "accurate", these claims have just as often been challenged. Claims of objectivity and accuracy are "misleading" because what is measured, how it is operationalized and how it is interpreted is always subject to decisions and thus to limitations and bias (Boyd and Crawford, 2012). Metrics are shaped by those who design them. They are proxies for what their creators "care about" (Thomas and Uminsky, 2022). Metrics tend to overemphasize short-term concerns. They "can, and will, be gamed" (ibid.). Celonis' systems for the management, optimization and automation of operational processes largely rely on particular metrics, which are often preconfigured. These metrics guide, and possibly sometimes determine, how employers and their managers make decisions about how work will be carried out and by whom. As such, these metrics can be considered an element of algorithmic management themselves.

As detailed in section 2.7, Celonis claims that its software is "designed" according to the GDPR concept of "**data protection by design and default**". It disclaims, however, any responsibility by emphasizing that it is "highly configurable" and customers would be "in full control of any personal data uploaded". Employers are certainly primarily responsible for how they process data on workers and parts of the system can, in theory, be used without processing any personal data about them. While some organizations may use the system to analyze process data in a one-off project over a short period of time, others may use it to continuously manage and monitor workflows and activities in the long term. The design of the system, its documentation and the way Celonis promotes its use, incentivizes employers to process large amounts of personal data from a wide range of enterprise software systems. Some functionality in the process mining system is only available when the activity records contain information about the employees who performed certain activities. Celonis' workflow automation and system integration technology facilitates the rapid expansion of data flows and functionality across many enterprise systems.

While a legal assessment is beyond the scope of this study, the examined data practices clearly raise concerns with regard to European data protection legislation. Some examples in the investigation show personal data processing at an extreme scale and depth, potentially covering employee behaviors and activities throughout the entire working day. The complexity of the technology, which offers a multitude of functions that potentially involve data flows across several enterprise systems, makes it opaque and difficult to understand for employees. This also poses the risk of undermining "purpose limitation", a key principle of the GDPR.[301]

[301] See e.g. Bentzen, Heidi Beate (2022): Context as key: The protection of personal integrity by means of the purpose limitation principle. In: Eleni Kosta, Ronald Leenes, and Irene Kamara (Eds.)(2022): Research Handbook on EU Data Protection Law. Edward Elgar Publishing Ltd

(4) Analysis of behaviors and interactions on desktop computers. In addition to the use of extensive personal data about workers and work activities based on time-stamped activity log data from different enterprise software systems, Celonis offers another even more intrusive technology it refers to as "task mining", which records and analyzes personal data about behaviors and interactions performed by workers on their desktop computers. As table 3 (4) (b) summarizes, the system can capture data on screen, application, email, browser, keyboard and mouse usage, including very sensitive data ranging from texts entered to communication, clipboard and screen contents.

Celonis module/functionality	(b) Mechanisms that rely on extensive personal data processing about work activities and workers, but do not expose or utilize personal data in their output	(c) Mechanisms that expose personal data about workers in their output, single out workers at the individual level or act on them, e.g. by making decisions about them
(4) Analysis of behaviors and interactions on desktop computers Celonis "task mining" technology (section 5)	• Record extensive personal data about behaviors and interactions performed by workers on their desktop computers, including on screen, application, email, browser, clipboard, keyboard and mouse usage (section 5.1) • Optionally record very sensitive data, e.g. text entered, communication content, clipboard content, screen content, and mouse clicks and scrolls (section 5.1) • Document workflows and tasks performed on desktop computers, extract knowledge, use it for "training purposes" and "automation initiatives" (section 5.3.2) • Combine desktop interactions with activity and log data from enterprise systems, group desktop interactions into work activities (section 5.3.1, 5.3.4) • Analyze "user behavior", "behavioral patterns", application use, websites visited, copy and paste activities, duration of activities like "writing", "typing" and "clicking", and number of occurrences of particular keyboard commands (section 5.2, 5.3.3) • Analyze particular activities in particular applications, Excel sheets or SAP modules (section 5.3.3) • Detect "inefficiencies", identify "improvement potential across teams", identify "optimization opportunities", decrease the time spent on "non-value adding activities" (section 5.2, 5.3.2) • Measure and optimize "workforce productivity", "task productivity" and "efficiency"; calculate a "productivity score", quantify "productive", "unproductive", "case-related" and "idle" time (section 5.2, 5.3.3, 5.3.4) • Assess "compliance" based on detecting "noncompliance flows" and "unusual events" (5.3.4) • Assess "task productivity", "idle time" and other metrics in relation to target values (section 5.3.4) • Compare "productivity" and other metrics across teams and other groups of workers (section 5.3.3) • Identify "training needs" (section 5.2, 5.3.2)	• Access detailed log information on desktop interactions including screenshots in a way that can hardly be considered as anonymized (section 5.1, 5.3.2) • Analyze desktop data at the individual level, per "user", i.e. worker (sections 5.2, 5.3.4) • Display extensive metrics about desktop computer usage and work activities at the individual level, including on "user level effort", "case related time spent per application", "idle time"; activities like "working on mail" and on the duration of activities (as suggested by the findings in section 5.3.4) • As a result, monitor worker behaviors and performance • Track "which users might need training or support to reduce operational costs" (section 5.3.4)

Table 3: Mechanisms and data practices identified in this investigation

Celonis suggests using the recorded data to document workflows and tasks performed on desktop computers, and thus to extract knowledge. Data about desktop interactions can be grouped into "activities" and combined with data from activity logs from enterprise software systems. Celonis also suggests using task mining to detect "inefficiencies", identify "improvement potential" and "optimization opportunities" and decrease the time spent on "non-value

adding activities". Its "**workforce productivity**" application utilizes the recorded data to analyze the behaviors of employees, such as the applications used, websites visited, copy and paste activities, the duration of activities like "writing", "typing" and "clicking" in particular applications, Excel sheets or SAP modules and the number of occurrences of particular keyboard commands. The application promises to measure and optimize "workforce productivity" by calculating "productive times" and "productivity scores". While the latest version of the application, according to corporate sources, displays comparisons of productive scores only for teams and other groups, earlier versions appear to allow filtering of all analysis results by particular employees.

As summarized in table 3 (4) (c), Celonis provides access to detailed log information on each captured desktop interaction including screenshots in a way that can hardly be considered anonymized. A third-party application provided by IBM and presented on the Celonis website appears to analyze extensive data on desktop interactions and work activities at the level of **individual employees**. It combines desktop data with activity log data and calculates metrics about activities like "working on mail", the "user level effort", "case related time spent per application" and "idle time". At the aggregate level, it calculates metrics about "task productivity", "idle time" and "compliance", the latter of which is based on detecting "noncompliance flows" and "unusual events". These metrics are displayed in relation to expected target values. While the application does not display the names of employees but pseudonyms, IBM suggests using it to "track which users might need training or support to reduce operational costs and which applications are mostly used". This example application suggests that Celonis' task mining system can be used for behavior and performance monitoring at both the group and individual level.

As detailed in section 5.5, Celonis claims that its task mining system is "designed and developed with a focus on **data protection** principles" under the GDPR. Employers can include or exclude particular applications from being tracked and customize the captured data categories. They can activate pseudonymization and "hashing" to obfuscate identifiable attributes and text content. As the recorded data always includes an employee's Windows username, the system generally collects personal data. It appears that the tracking software cannot be installed on an employee's desktop computer without them at least being exposed to a notice. Users can "pause" data collection, which is, however, visible in status reports. Celonis suggests using "consent", "employment contract" or "legitimate interest" as a legal basis under the GDPR, all of which are at least questionable in most EU countries. One practical example presented by Celonis involves capturing data from 40 employees for 10 days. Another example involves 2,000 workers. According to the company, the system is able to capture up to **1.6 billion desktop interactions from 2,500 employees over six months**.[302] While Celonis "advises" its clients to consult "data privacy experts" and the "workers council" ("if applicable") before activating task mining, it also prominently suggests, somewhat contradictorily, that employers could set up the "workforce productivity" application "in less than 10 minutes".

7.2 Concluding remarks

This investigation explores, examines and documents how software from Celonis, which was selected as an illustrative example of wider practices, uses large amounts of personal data about workers and work activities to help organizations optimize, automate, manage and monitor how work is carried out. While employers can certainly use these technologies in ways that are beneficial for everyone, the findings in this case study suggest that organizations may utilize them to unilaterally streamline and reorganize work according to their business goals while making workers subject to disproportional digital monitoring and control. The unscrupulous exploitation of worker data at

[302] See section 5.3.3.

scale increases the power imbalance between employers and workers and normalizes extensive surveillance in the workplace. While these technologies could, in theory, also be used to optimize work towards goals like better working conditions and increased employee wellbeing, Celonis almost exclusively emphasizes optimization towards the most ordinary and aggressive business objectives like increased efficiency and lowered costs.

McKinsey as a cloud service? McKinsey, the consulting giant, has faced its fair share of criticism for prioritizing cost-cutting above all else. Duff McDonald (2013), in his book about the firm, pointed out that hiring McKinsey can be both a symbolic gesture and a practical move. The decision can create anxiety among the client's executives and employees. McKinsey might be the world's "single greatest legitimizer of mass layoffs", as Duff put it. Celonis promises its clients to "make cutting cost, cost less".[303] Perhaps it could be seen as a technology-driven version of McKinsey. While McKinsey relies on management buzzwords to legitimize what it does, Celonis uses what has been called tech and data solutionism (Morozov, 2013), the belief that technology and data can fix everything, to justify its services.

Workers and union representatives can only be advised to carefully examine the possible introduction of such a system in a company and demand the highest possible level of information and participation.

The findings of this case study will be incorporated in the main report of the ongoing project "Surveillance and Digital Control at Work" (2023-2024), led by Cracked Labs, which aims to explore how companies use personal data on workers in Europe. The main report will draw further conclusions.

List of figures

[303] https://www.celonis.com/solutions/shared-services/ [2.8.2023]

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