Baltic J. Modern Computing, Vol. 13 (2025), No. 1, 129-156
https://doi.org/10.22364/bjmc.2025.13.1.07

Conceptual Model: Personal Information Management Using Adaptive Information Systems

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Abstract. In the digital age, information overload is a widespread issue that hampers the efficient management of large volumes of personal data. Considering solving this problem, this study aims to develop and test a conceptual model of an adaptive personal information management system (AIS). The information system can be adapted to suit individual users' preferences and tasks. The study uses a mixed methods approach, combining quantitative and qualitative data collected through expert assessments using the Delphi method, modeling scenarios, and literature reviews. The AIS framework, validated by experts, focuses on centralizing, classifying, prioritizing, and filtering information based on user behavior and preferences. Simulations indicate that the AIS can reduce cognitive load and enhances information processing efficiency. This paper discusses the implications of these findings and offers recommendations for adaptive systems integration in personal information management.

Keywords: Adaptive Information Systems, Information Overload, Personal Information Management, Context-Awareness.

1. Introduction

Personal information management (PIM) in today's digital environment faces major challenges due to the exponential growth of information and data sources. People frequently feel overloaded with information, which impairs their ability to be productive and make wise decisions. Managing large amounts of data, storing personal information in different formats across numerous devices, managing various kinds of personal information, and projecting the future value of personal information are some of these challenges (Jones, 2017). Individuals put a lot of time and energy into organizing their data, but they frequently find it challenging and ineffective (Oh, 2019).

Due to human uniqueness, all people have different information preferences, backgrounds, levels of education, methods for processing information, and cognitive capacities (Arnold, 2023). Humans are unique and have individual information demand and processing capabilities. These requirements raise a significant concern about information systems' inability to address information overload with a "one approach fits all" solution.

Adaptive Information Systems is a relatively new research area that lies at the intersection of Information Science, Human-Computer Interaction, and Artificial Intelligence. It offers an alternative to the traditional "one-size-fits-all" approach in Information Systems development. These systems create a model based on each user's goals, preferences, and knowledge, and use this model throughout the interaction to tailor the system's responses to the user's specific needs (Palm, 2020).

The current study introduces a conceptual model of an adaptive personal information management system. This model incorporates various user characteristics that contribute to calculating the information overload ratio. Based on this ratio, the system triggers actions aimed at reducing information overload for the user. By focusing the measurement of information overload, the system adopts a proactive approach to enhancing the user's information management experience. The study also demonstrates simulation results for two scenarios: when user experience information overload and when AIS triggers actions to mitigate it

2. Purpose of the Study and Research Design

The primary aim of this study is to develop a conceptual model of AIS that effectively manages information overload by adapting to individual user characteristics. The research addresses the following hypotheses and questions:

Hypothesis: An Adaptive Information System that considers individual user characteristics will reduce user information overload.

Research Questions:

1. How can AIS identify information overload?
2. What strategies can be used to reduce information overload?

Research Design: The study employs a mixed-methods approach, combining qualitative and quantitative research methods. It involves:

1. Literature review to identify factors contributing to information overload.
2. Design and development of the AIS model.
3. Expert assessment using the Delphi method.
4. Simulation scenarios to validate the model.

3. Literature Review

Existing research highlights the adverse effects of information overload on cognitive performance and stress levels. Studies by Baskerville (2011) and DesAutels (2011) underscore the necessity for personalized information management solutions. However, modern systems lack adaptive mechanisms for dynamically adjusting user behavior and preferences. This research gap necessitates the exploration of AIS, which integrates principles from Information Science, Human-Computer Interaction, and Artificial Intelligence to offer a tailored user experience.

3.1. PIMS

In 2011 Richard Baskerville in the article “Individual information systems as a research arena” described the phenomenon named Personal Information Management System. He identifies a significant lacuna in the scientific literature that fails to adequately describe how individuals interact with information and information systems. This oversight is notable, as most scholarly attention is devoted to complex organizational systems, often neglecting the nuanced ways in which individuals engage with information systems in their daily lives (Baskerville, 2011).

Baskerville questions the overarching emphasis on organizational systems within research, urging a reevaluation of the roles personal systems play. He argues that individuals are not merely passive consumers or recreational users of technology; rather, they actively manage, curate, and utilize information to fulfill diverse personal and professional roles. This active engagement with information extends beyond traditional computing environments to include interactions with a broader digital ecosystem, encompassing social media, the Internet of Things, and beyond.

Warraich (2018) and Hwang (2015) further elaborate on the capabilities and significance of PIMS, noting that these systems are not only about managing and storing traditional data like documents and emails but also about seamlessly integrating user data across diverse platforms. PIMS employ advanced technologies such as semantic search layers and personal ontologies to enhance the meaningfulness of data and support sophisticated data analysis and mining capabilities. These functions facilitate the creation of a personalized information environment where tasks and information are synchronized across devices and platforms, enhancing both user connectivity and insight.

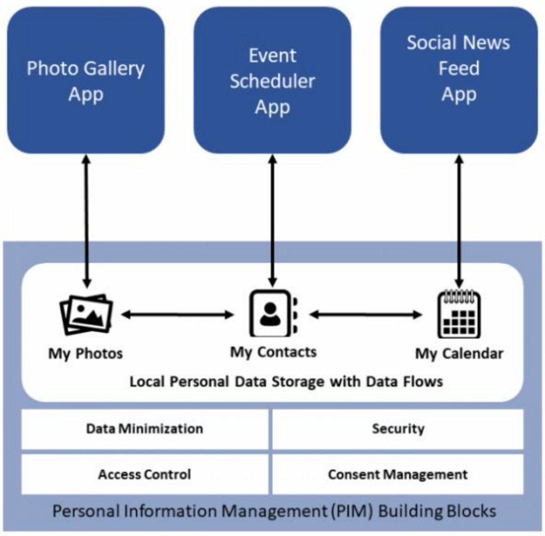

Figure 1. Schema for a Personal Information Management System with a local personal data storage (Attoresi, 2020).

However, it is critical to note that the idiosyncratic nature of PIM practices means they vary significantly across individuals, shaped by specific personal needs and environmental affordances (Warraich, 2018). This variability presents a challenge for designing universally effective PIMS, as the "one-size-fits-all" approach is often inadequate. Therefore, further research is necessary to understand the diverse ways in which different users interact with PIMS and to develop adaptive systems that can cater to this wide range of user behaviors and preferences.

By shifting the research focus from predominantly organizational information systems to include individual-oriented studies, scholars can better understand and enhance the efficacy of personal information management in our increasingly digitized lives. This approach will also allow for a more nuanced understanding of how personal information management systems can act as integral components of modern digital infrastructures, effectively bridging the gap between individual needs and technological capabilities.

3.2. Information management organization process

Variety of information about people's lives and activities is included in the definition of personal information. Jones (Jones, 2007) states that there are several ways in which one may use the term "personal information," such as information that an individual retains for their own use, information about an individual maintained by and controlled by third parties, and information that an individual experiences but is not in control of. It's important to keep in mind that personal information can come in a variety of formats, including paper and electronic documents, emails, web references, handwritten notes, materials related to work, music, videos, photos, financial information, and records of various interactions, including phone conversations, emails, and web browsing history (Jones, 2007, Widjaja, 2019). It also emphasizes how sensitive information may vary depending on the kind of data; among the most sensitive categories of data include financial information, identity, and personal papers. Widjaja suggests that while utilizing cloud storage services, consumers may perceive varying levels of privacy and security dangers connected with different categories of personal information (Widjaja, 2019).

Information organization includes the ability to gather, store, organize, preserve, retrieve, use, and share personal information in an efficient manner. This process involves several actions and steps, such as identification, comparison and examination, creation and modification, initialization, and temporary classification. These phases illustrate the steps, ideas, choices, and elements involved in a comprehensive organization of personal data. Those who keep things organized can boost output, make information easier to access, get reminders for activity management, and help people learn the material better. This procedure is required to guarantee that people safeguard their private data and maximize their time, money, and energy (Oh, 2023).

Jones has introduced term "personal information space" which refers to a person's domain that contains personal information items over which the person has at least a minimal amount of control. Books, paper documents, e-mail correspondence, e-docs, and other files are included in this area, along with links to websites and programs that facilitate the gathering, storing, retrieving, and use of information (Jones, 2007). In addition, the personal information space includes structures that help with information management, including folders and related characteristics (Jones, 2007).

The PIS model consists of a person's unique personal space of information, incorporating a range of personal information items that are, at least nominally, under the person's control. This model delineates the actions, thoughts, and decisions involved in the organization process and identifies factors that impact the process, offering valuable insights into personal information organization (Oh, 2022).

Three primary components comprise Jones' concept:

- Keeping: Input tasks that help create and preserve a personal information space are among the primary tasks carried out by personal information management systems.
- Finding: Extracting data from private areas.
- M-level activities: The term "M-level activities" describes the information-related managerial tasks that people perform. These tasks need more comprehensive and strategic measures linked to efficiently managing and arranging personal data. This involves tasks including keeping data organized, preserving privacy and security, managing information systems, assessing the efficacy of information management plans, and deciphering personal data.

These activities are central to managing personal information effectively and efficiently within the PIMS framework (Kearns, 2014). It is crucial to consider how these elements are connected to task loading and human-computer interaction in order to give a summary of the "Money, Energy, Time, and Adjustment" (META) principle (Szalma, 2007). According to the principle, in contexts involving human-computer interaction, these four factors are critical in determining task performance effectiveness and stress levels. Each component has an impact on how users interact with interactive tasks and how they perform as a result. People can improve their interactions with technology, effectively manage cognitive loads, reduce stress, and improve task performance and user satisfaction by striking a balance between resources like money, energy, time, and adjustment.

3.3. Decision making in personal information management

An individual's decision-making processes can be greatly impacted by how people arrange and manage their personal information. Having easy access to pertinent information, lowering cognitive load, and promoting more informed decisions are all ways that well-organized information can improve decision-making (Bergman, 2008). Stress levels, cognitive load, task complexity, and individual capabilities are the factors that influence on decision making and are essential components to human-computer interaction and influence how decisions are made (Szalma, 2007).

3.4. Issues and challenges in personal information management

There are several challenges for humans while working with PIM: such as information fragmentation, challenges locating and retrieving information, information value volatility, difficulties dealing with the sheer volume of information, and obsolescence of technology. Web-based information, email, and desktop computers are just a few of the crucial domains that have identified as requiring information management (Jones, 2007)

The study highlighted several issues related to information management across various demographics, underscoring not just information overload but also "filter failure" as critical concerns (Kearns, 2014). Challenges include the difficulty of managing abundant online information (Majid, 2010), fragmentation across devices leading to inefficiencies and data loss (Majid, 2010), and the emotional and practical burdens of managing health-related information (Sannon, 2023). Additionally, security and privacy concerns are particularly pronounced among young adults using internet services (Majid, 2010). The study also noted significant dissatisfaction with current methods for handling household information (Sannon, 2023).

People often experience frustration and time loss when they struggle to find important information quickly, which can lead to feelings of confusion, helplessness, and irritation. Fragmented data, spread across multiple devices or tools, intensifies issues of information overload, reducing productivity and efficiency (Chaudhry, 2015). Additionally, the increasing diversity of information formats and technologies complicates information management, leading to mistakes and poor decisions about data storage that hinder information retrieval (Jones, 2007).

3.5. Information overload

When people believe they are getting too much information, it is impeding their ability to complete tasks, a negative psychological state known as information overload occurs. Emotional and cognitive difficulties are indicators of information overload, which is most likely caused by intrinsic and extrinsic information characteristics, poorly defined information needs, the work environment, or the information environment. Internal and external consequences arise from the emotional and cognitive manifestations. Poor decision-making can have a negative impact on finances and human resources(Bellabes, 2022).

Ineffective information management practices lead to information overload, which in turn impairs information retrieval. The ease with which vast amounts of information can be accessed via a variety of devices exacerbates this issue. Every new technological advancement contributes to the already-existing information overload by making information production, acquisition, and dissemination even simpler and less expensive (Majid, 2010). When staff members don't have enough time to read, comprehend, and make use of the information that is available, information overload happens. When attempts to locate information are unsuccessful, this leads to frustration. This may result in anxiety, which can then lead to headaches, dizziness, disorientation, helplessness, and irritation and annoyance.

Excessive amounts of potentially helpful and relevant information can impede rather than assist people in their tasks, according to descriptions of the phenomenon (Bawden, 2020). Information diversity, complexity, choices, confusion, and harm are all relevant factors to consider in addition to its quantity (Bawden, 2020). The idea of information overload has also been linked to the connection between an abundance of information and a sense of psychological overload (Mostak, 2014). Comprehending the complex characteristics of information overload entails taking into account both the subjective reaction of each individual to the information as well as its objective quantity and quality (Mostak, 2014). Another aspect the concept of "information noise" embodies a diverse array of perspectives and interpretations, reflecting the multifaceted nature of the term (Spira, 2012). It's associated with the perception of excessive or irrelevant data, which hinders the efficient processing and utilization of pertinent information. The impact of information noise on individuals and organizations can be profound, contributing to factors such as inefficiency, misinformation, and reduced decision-making capacity (Bawden, 2020). In general, information overload is problematic because it has been associated with diminished reasoning ability and decision quality, poorer memory recall and feelings of confusion, stress, and anxiety (Schick, Gordon & Haka, 1990). Various attention deficit problems are thought to be associated with information overload Rose, 2010).

3.6. Notification's disruption

Several studies demonstrated that the number of incoming messages can in fact considerably add to information overload (Kumar, Shrivastav, 2013). A deluge of information may result from the ease with which information is shared and accessed, particularly with the use of digital workplace tools and various communication platforms. This can make it difficult for people to sort through and handle the volume of messages (Kumar, 2013).

Lowered notification-related disruptions may ultimately result in increased productivity, according to empirical data. They are reported that, there is a possibility that with fewer notifications interfering with work, individuals may perform better and become less irritated within the day. These disruptions are viewed as stressors that prevent people from meeting objectives on important tasks, jeopardizing daily targets and causing anxiety (Ohly, Bastin, 2023).

3.7. Consequences of information overload

Information overload, cognitive load, security worries, and privacy issues are just a few of the drawbacks of digital information processing. Numerous studies and literature sources demonstrate these impacts (Sannon, 2023). For example, emphasizes how handling digital information can be cognitively taxing, making decision-making and retrieval difficult. Additionally, it has been observed that the existence of digital information overload raises the risk of security breaches, anxiety, and stress (Mahler, 2020, Majid, 2010).

Poor organization and difficulties with predictability resulting from mishandling personal digital information can cause a decrease in productivity and an increase in stress (Jones, 2007, Warraich, 2018). Focusing too much on digital document management, especially with ineffective tools or techniques, can take a lot of time and mental energy, which can lead to frustration and decreased productivity (Jones, 2007). As explained by Sanon (Sanon, 2023), the primary underlying causes of information overload and cognitive load include things like being overexposed to information, the speed at which technology is developing, and the incapacity to effectively handle and process information (Mahler, 2020). Decision-making, mental workload, and job satisfaction suffer because of these underlying causes, which also lead to increased information processing, shorter task completion deadlines, and more pertinent information than can be processed (Mahler, 2020).

3.8. Mitigating information overload

Information overload won't affect those who prefer to receive little to no information but are presented with a lot of it because they won't process it all. There are several strategies to mitigate information overload, including instituting email policies to limit excessive communication, storing knowledge in repositories, and filtering and arranging information flow. In addition to addressing concerns about the quantity and caliber of information shared within the organization, these actions aim to lessen the burden that information overload is putting on individuals who are experiencing it (Mahler, 2020). The prevention and recovery strategies that are examined to lessen cognitive fatigue and information overload include a range of approaches. Taking notes, sticking notes on the wall, and organizing paperwork are examples of preventative measures that one can use to ward against potential forgetfulness and serve as a reminder of helpful tools (Elsweiler, 2007).

To lessen the cognitive load associated with information management, techniques like active document triage and the use of passive information management tools like auto filtering and tagging options (Sanon, 2023).

The effectiveness of PIM can be influenced by an individual's cognitive processes, which include their mental strategies for information processing, organization, and retrieval (Kearns, 2014). Furthermore, knowing one's preferred ways of thinking and learning can help create customized PIM strategies.

As result create comprehensive and individualized information management strategies, it is crucial to consider cognitive, behavioral, and technological aspects of PIM when analyzing individual factors.

The authors do not exclude using other pedagogical methods that can help to develop students' critical thinking, such as flipped classrooms (Vdovinskiene, 2023). Creating an individualized learning experience that meets each student's unique needs, preferences, and learning speed is a key component of adaptive learning to user behavior. Using user models to automate the learning process, this method uses adaptive learning management systems, which modify learning paths and content delivery in real-time in response to assessments of a learner's engagement and level of knowledge. Through constant observation and adjustment to user conduct, these systems seek to improve student performance and guarantee that the educational process is as efficient and pertinent as feasible, ultimately cultivating a more customized and encouraging learning environment (Jurenoka and Grundspenkis, 2023).

3.9. Adaptive information systems

Adaptive Information Systema is a management information system adapting its user interface and interaction strategy depending on user preferences and past user behavior and satisfaction (Höpken, 2018). Based on perceived changes in the environment, system conditions, and requirements, it entails altering its structure, parameters, and behavior at run time. The system's ability to adapt lets it function well in a variety of situations. To learn more about the concept of "behavioral adaptation," we can consult pertinent information in (Shuetz, 2020), a document that addresses the adaptability of Cognitive Computing Systems (CCS). Behavioral adaptation refers to the ability of CCS to adjust their actions over time to achieve improved outcomes. By utilizing adaptive features, this unique capability allows for the creation of more effective systems that meet user preferences and needs more effectively.

The system should be made to be able to adapt to changing environments without breaking down in order to maximize human performance within an adaptive system. When we talk about the adaptive aspect of AIS, we mean the system's capacity to adjust to external stimuli while maintaining its functionality. The capacity for adaptation enables any system, be it artificial or biological, to adjust efficiently to changing circumstances and increase overall performance (Kovacs, 2004).

Understanding the mechanisms through which adaptation takes place is essential to understanding how adaptivity functions in adaptive systems. Adaptive systems use a variety of techniques for self-adaptation, such as keeping an eye on their surroundings and changing course when necessary. One strategy makes use of online reinforcement learning, in which the system gains knowledge about the efficacy of adaptation actions through real-time interactions with its surroundings (Palm, 2020). By having the system learn and modify its behavior based on predetermined learning goals, this approach improves the system's adaptability without requiring manual intervention, thereby automating the task of developing self-adaptation logic. Instead of requiring information system engineers to manually create self-adaptation logic, systems can now learn it automatically through the integration of online reinforcement learning. This method lets the system learn and adapt in real-time through machine learning, automating the laborious engineering task of creating self-adaptation logic (Palm, 2020).

Additionally, in the context of human-machine interaction, the cognitive effects of prolonged continuous use require adaptive interfaces that can recognize impaired cognitive states and modify the interaction to maintain efficiency and safety (Palm, 2020). These mental state-based adaptive systems use a variety of metrics to determine the operator's current mental state, then adjust the interaction accordingly. Changes in task scheduling, information presentation, or stimulus salience may all be part of the adaptation, which is intended to counteract performance decline brought on by extended interaction.

3.10. Research gap

The development and comprehension of technologies that can centralize information flow and dynamically adapt to user behavior and preferences remain largely unexplored, despite the existence of research in personal information management and personal information management systems.

Current PIM systems manage information in a fragmented way, with different tools and apps dealing with emails, calendars, tasks, and social media. Research is needed on technologies that can bring these disparate information sources together into one cohesive system. Centralizing information flow can make management easier, eliminate duplication, and offer a complete overview of all user activities.

Although there may be some degree of customization available with current systems, there aren't many cutting-edge adaptive technologies that can automatically modify and optimize information management procedures based on user interactions and behaviors. Research ought to concentrate on creating adaptive PIM systems that dynamically customize the user experience based on real-time behavior and preferences by utilizing artificial intelligence and machine learning.

System awareness and adaptability to various user contexts are necessary for effective PIM (e.g. work, private, and social). Investigating the potential of contextual data, including time, location, device usage, and user activity, to customize information management tactics requires more research. By minimizing cognitive load and preserving productivity, context-aware PIM systems enable users to move between contexts with ease.

4. AIS Conceptual Model Development

The AIS conceptual model was designed, and data was collected using a combination of qualitative and quantitative research methods. This mixed-approaches approach guaranteed a comprehensive understanding of the problems associated with information overload and the efficacy of the AIS. The requirements for the conceptual model were initially established and later verified by professionals. Expert suggestions were also incorporated into the design of the conceptual model. The study ends with simulations that explore the scenario of information overload and AIS impact on it.

The initial conceptual model of the AIS developed based on a review of existing studies and theories in personal information management, information overload, and adaptive systems. This model aimed to address key challenges in managing information overload by incorporating adaptive mechanisms, user-centric design principles.

To validate the conceptual model, the Delphi method was employed to get expert opinions. Experts were selected based on their extensive knowledge and experience in information technologies. In the Delphi method were included closed-ended questions to gather quantitative data on the frequency of experiencing information overload and the perceived efficacy of features offered by the AIS. Among the expert responses, these data were utilized to find patterns and trends.

The simulation environment for assessing the Adaptive Information System (AIS) was constructed using AnyLogic software, which enabled detailed modeling of the AIS and its components. Two primary scenarios were devised to mirror real-world conditions and evaluate the system's impact: the first scenario, "Without AIS," served as a baseline for measuring the typical extent of information overload, while the second scenario, "With AIS," was used to evaluate the effectiveness of the AIS in significantly reducing information overload.

To simplify the management of information overload, the model introduces the concept of an Activity. An activity represents an information item, (an email, note, or task etc.) and includes a number the actions required to process this information item. By referring to information items as activities, the AIS can better organize, structure and manage personal information. The number of activities collectively creates the total volume of information that the user must process. The Context is specified, which indicates the environment or situation in which the activity occurs. It helps to understand the background or setting of the activity. The actions are connected sequentially, indicating the order in which they must be performed.

Figure 3 shows how activities and the actions that go along with them add up to the total amount of information that a user must process. This helps to visually represent the idea of information load within the AIS for Personal Information Management.

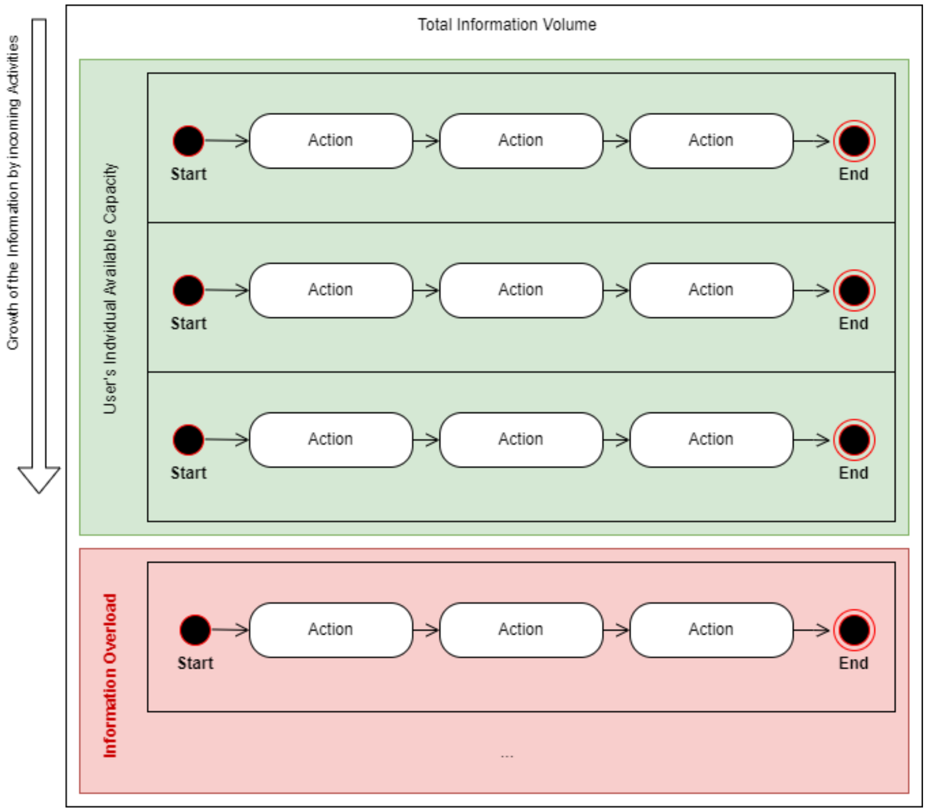

Figure 2. Information in context of AIS

At the top, the diagram introduces the concept of Information as the top element being managed. This information is broken down into a Collection of Activities, each representing a specific information item, such as an email, note, or task. The Individual Capacity axis on the left side of the diagram represents the user's cognitive ability to process information. This capacity influences how many activities and actions a user can handle without experiencing information overload. The Total Information Volume axis on the right side of the diagram indicates the cumulative amount of information generated by the activities. The number of activities and the complexity of their actions collectively determine the total volume of information a user needs to manage. All activities and their corresponding actions add up to the total information volume that the user needs to process.

In the study, was chosen scenario to demonstrate how the AIS handles information overload and simulate a situation in which a user is distracted by a new activities and switching their attention on it and delaying other ongoing tasks.

In this scenario, the user is involved in multiple activities with different contexts (e.g. work and private).

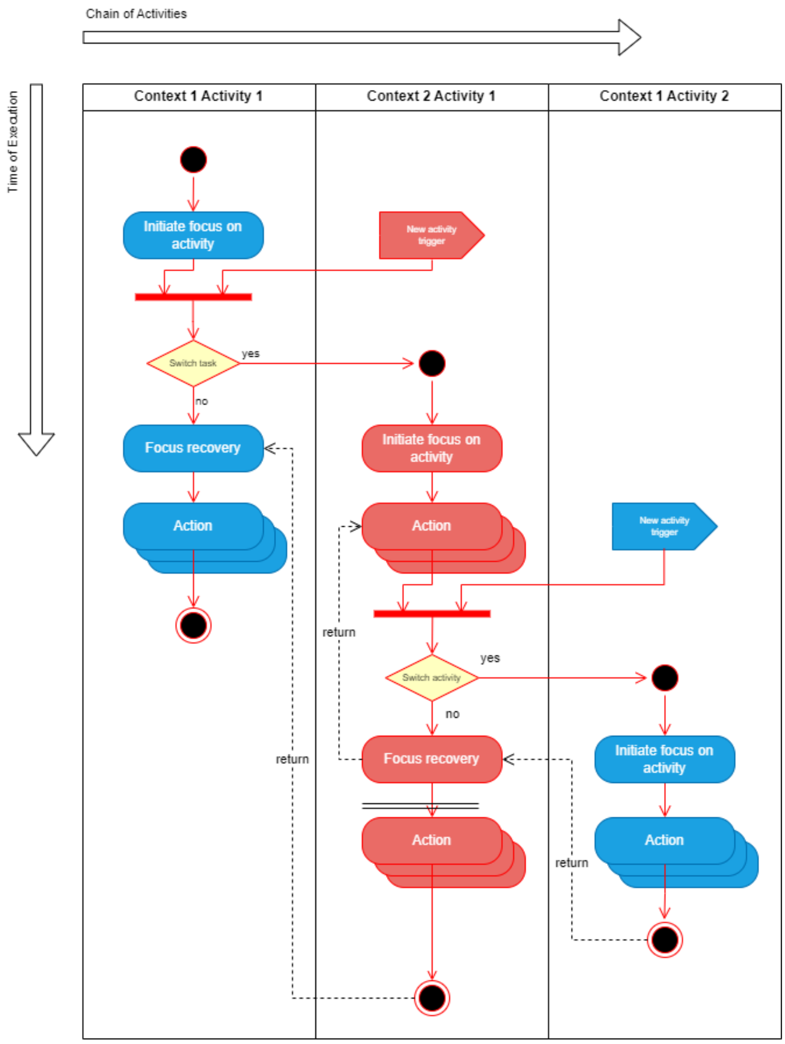

Figure 3. Distracting the user and switching between activities

The flowchart (see Fig. 4) illustrates the sequence of activities and decisions involved when a user is interrupted by a new activity. The user begins by initiating focus on Activity 1 within Context 1. This involves starting the sequence of actions required to complete the task.

When new activity (Context 2, Activity 1) is triggered and interrupts the current task. The user decides whether to move to the new activity based on priority and context. If the new activity is deemed important, the user switches to Context 2, Activity 1. The user initiates focus on Activity 1 in Context 2, temporarily leaves the previous task, and performs the actions required by Activity 1 in Context 2. After completing the previous task, the user returns to Context 1, Activity 1.

User interference can lead to information overload, forcing the user to switch to another activity. When the user returns to the previous activity, it can take up to 22 minutes to fully engage with the task again, according to recovery time research (Mark et al., 2008). Additionally, frequent glitches negatively impact task completion and contribute to delays, further increasing the user's cognitive load and reducing overall productivity.

Classifying new activities by priority and determining whether the user should switch tasks, the AIS can efficiently manage interruptions. This promotes maintaining productivity and dealing with distractions. Simulation demonstrates the AIS's ability to manage information overload by prioritizing tasks, minimizing unnecessary context switches, and incorporating focus recovery periods.

Simulation without AIS regulation

The main objective of this scenario is to evaluate the baseline performance of the Personal Information Management System with adaptive features disabled. In this scenario, the system functions normally and without adaptive intervention. Incoming data is not subject to filtering. The user receives all information as he receives it, without any prioritization or classification. This scenario is intended to illustrate the difficulties and problems that often arise in non-adaptive systems, including possible interference from frequent and unfiltered notifications and information overload. Metrics to watch include the start and completion time of user activity.

Simulation with AIS regulation

The goal of this scenario is to demonstrate how the AIS works and the benefits it provides when its adaptive features are enabled. The focus is on how the AIS can reduce information overload through intelligent interventions. In this scenario, the adaptive system - including information filtering - works as intended. The system dynamically adjusts the criteria based on the user's preferences and current tasks, as well as preset criteria for filtering incoming data

4.1. Calculating information overload

In order to effectively manage personal information and prevent information overload, the AIS requires a reliable method to calculate and assess the user's information load. In this study a simplified equation was developed based on Jackson formula (Jackson, 2012) and derived from the concept of activities described previously. The first step in calculating information overload involves determining the capacity required for each activity. An activity is comprised of multiple actions, each with its own processing time. The total required capacity for an activity is calculated as follows (see Formula 1):

$$Activity\ Required\ Capacity = \sum_{i=1}^{n} Action\ Processing\ Time_i \qquad (1)$$

Once the required capacity for each activity is determined, the overall information overload can be assessed by comparing the total required capacity of all activities to the user's available capacity (see Formula 2):

$$Information\ Overload = Available\ Capacity - \sum_{i=1}^{n} Activity\ Required\ Capacity_i \quad (2)$$

In this context:

- If the value of Information Overload is < 0, it indicates that the user is experiencing information overload.
- If the value of Information >= 0, it indicates that the user is not experiencing information overload.

This equation considers the total required capacity for all activities and compares it to the available capacity of the user. The AIS calculates the metrics of every action and adjusts them according to user behavior to determine if the user has enough time to process the information.

4.2. Adaptive System Framework

The conceptual model self-regulation component was designed using the MAPE-K framework, which is proposed for use in self-regulation systems. MAPE-K (Monitor, Analyze, Plan, Execute, Knowledge) represents a conceptual framework for building self-adaptive systems that can adjust behavior in response to changes in the environment or the system itself. The MAPE-K loop provides a structured approach for designing systems, emphasizing the importance of a continuous feedback loop supported by a knowledge base (Iglesia, 2015).

4.3. Additional functionality considerations

The model should ensure seamless cross-platform functionality, allowing consistent access and management of information across various devices through a unified network. It should integrate diverse sources of personal information into a single platform and utilize advanced search and retrieval technologies like natural language processing. The system needs automated organization features and robust privacy and security measures, alongside scalability to handle growing data and user numbers. Additionally, it should support collaboration and secure sharing, continuously adapt to user preferences, and employ strategies to mitigate information overload, thereby enhancing user experience and efficiency.

4.4. Expert review process

A diverse group of experts was selected for their academic and professional expertise in personal information management, adaptive systems, and user experience design. The panel consisted of 11 experts. The experience levels of the experts varied, providing a well-rounded view of the issues related to information overload varies from <5 years to more than 20 years. In total participated 11 experts. 9 of the experts have bachelor's degree and 2 – masters.

All of them are actively practicing professionals, with most working in information technology and professional in marketing and sales.

4.5. Draft questionnaire

The questionnaire used in the study focused on several key areas to gather expert insights into the design and effectiveness of AIS. First, it addressed experts' personal experiences with information overload, asking them to describe the frequency and sources of such overload and the distractions they encounter. This helped to understand the real-world impact of information overload on professionals.

Second, the questionnaire explored the impact of these distractions on productivity and information management, probing how these interruptions affect daily work and efficiency. Third, it sought expert opinions on the potential of AIS to enhance productivity by reducing distractions and adapting to the unique preferences of individual users.

Additionally, experts were asked to identify crucial features and functionalities that an AIS should have to manage and reduce information overload effectively. They also discussed methods for measuring information complexity and overload, as well as strategies to mitigate these challenges effectively.

The questionnaire included both closed and open questions, allowing for structured responses and more detailed explanations. Feedback from these rounds was summarized and shared in subsequent rounds to refine the questions further and clarify any ambiguous areas, ensuring a comprehensive understanding of expert perspectives on AIS.

5. Simulation setup and execution

The simulation is performed using AnyLogic software and it was configured to model the AIS and its components: activities, actions and dynamic adaptation strategies.

5.1. Simulation

To determine the necessary number of simulations runs, a statistical formula was used to achieve a 95% confidence level with an 80% estimated proportion of observing information overload, and a 5% margin of error. This formula initially suggested 246 runs. However, given the practical considerations of each simulation's 14-day duration, authors adjusted the number to 25 runs per scenario (both with and without AIS enabled) to balance thoroughness and computational feasibility.

5.2. Synthetic data generation

For this study, synthetic data was created to mimic the environment and evaluate the effectiveness of the AIS. An Italian software company provided a data set that served as the basis for the synthetic data creation process and gave the simulation scenarios a realistic basis. The purpose of the synthetic data is to reproduce realistic user behavior and activity patterns, including typical distributions of activity types, frequencies, durations, and complexity levels. To ensure that the data adequately reflects typical user patterns of information management and information overload, additional insights and parameters from previous studies were included. The synthetic data set was created by applying random sampling techniques to these distributions.

5.3. Simulation data analysis and validation

To evaluate the AIS's impact on information overload, collected data was analyzed focusing on key performance metrics such as overload reduction, task completion rates, and user satisfaction. Statistical tests, specifically the McNemar test, were used to ascertain the significance of differences between scenarios with and without AIS intervention.

The analysis included six types of activities—Emails, News, Mobile Notifications, Task Assignment, Task Resolution, Task Charge—categorized into 'personal' and 'work' contexts, with a typical distribution of 25% personal and 75% work activities per day. Daily activities were set from 8:00 to 17:00, not exceeding 125 activities to simulate a realistic workday environment, with tasks generated from real-world data to inform the simulations.

Detailed Breakdown of Tasks

The creation of task activities is based on the analysis of dataset for one of its users. This real-world data provides a foundational basis for simulating work-related tasks and activities within the AIS model.

- Task Assignment:
  - Number of activities per day: 1
  - Duration: 1.14 hours (min: 0.0003 hours, max: 10.71 hours)
- Task Resolution:
  - Number of activities per day: 1
  - Duration: 3.47 hours (min: 0.0003 hours, max: 10.90 hours)
- Task Charge:
  - Number of activities per day: 2
  - Duration: 2.66 hours (min: 0.0008 hours, max: 11.17 hours)

Additional metrics in the study include title and content sizes, with titles averaging 75 words and emails ranging from 59 to 206 words, based on recommendations for optimal engagement. Newspaper content was set at 516 words. The recovery time after an interruption is standardized at 25 minutes. Task criticality varies with 54.72% of tasks being critical and lasting seven days, 30.52% rated high with a five-day duration, and 14.76% medium, lasting two days. The metrics 'ActivityRequiredTime' and 'AvailableTime' were employed to measure information overload, which is calculated hourly using a Information Overload formula (see Formula 2).

Validation AIS impact

The effects of AIS on managing information overload are validated using the McNemar test. The McNemar test was used to statistically evaluate whether the implementation of AIS significantly enhances information overload management compared to a baseline scenario without AIS intervention.

6. Conceptual model simulation and validation

6.1. Conceptual model design

The concept of how people manage personal information in a digital environment was explained by Baskerville and Gass (Baskerville, 2011, Gass, 2015), and this understanding served as the basis for the conceptual model design requirements. User-centered design, context support, cross-platform functionality, privacy and security, advanced search and query, automated organization, advanced search and query, and scalability are considered when designing the conceptual model.

6.2. Conceptual model framework

The conceptual framework for AIS emphasizes the centralization of both incoming and outgoing information. This centralization is critical to effective and efficient personal data management as it streamlines processes and reduces complexity for the user. The AIS acts as a central hub and enables better organization and handling of information, helping to mitigate problems such as information overload.

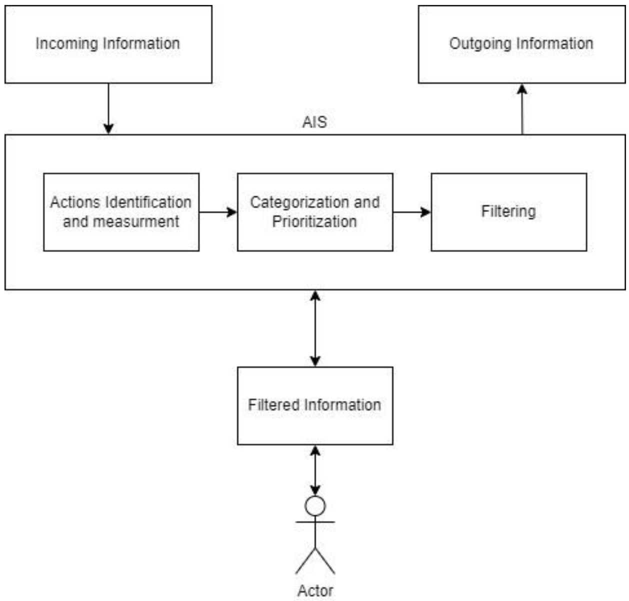

Figure 4. AIS framework

The AIS acts as a central hub (see Fig. 5) for all incoming and outgoing information. Incoming information includes all data coming from various sources such as emails, notifications, documents and social media updates. In order for this raw data to be useful to the user, it must be processed and managed. The AIS processes this information through several key components:

Action identification and measurement: This module identifies necessary actions based on the incoming information and measures relevant parameters such as urgency, relevance, and context. This step is crucial for understanding the importance and priority of each piece of information.

Categorization and prioritization: After identifying actions, the system organizes them into categories and assigns priority levels. This ensures that the most critical information is addressed first, helping the user to manage tasks effectively and efficiently.

Filtering: The filtering engine removes unnecessary or irrelevant information, ensuring that only the most relevant data reaches the user. This process includes relevance filtering, which eliminates information that does not meet the user's current needs, and spam filtering, which removes low-quality content.

After processing, the filtered information is presented to the user. This refined data is tailored to the user's preferences and needs and represents actionable and relevant information with which the user can interact. The user, referred to in this context as the “actor”, accesses this filtered information via the AIS.

Outbound information generated by the user's interactions with the AIS includes responses, new tasks, and actions taken based on the filtered information. This outgoing information is also managed by the AIS, which can further process or disseminate it as necessary, maintaining a coherent and organized flow of information.

Centralization within the AIS is key to better management of personal data. It simplifies the management process, reduces the time and effort required to process multiple streams of information, and ensures consistency in categorizing, prioritizing, and filtering information.

6.3. Assessment by Experts

The Delphi method was used to validate the conceptual model of the AIS. This process involved obtaining expert opinions through several rounds of questionnaires containing both closed- and open-ended questions. The aim was to refine the model and ensure that it effectively addresses the challenges of information overload. The process included three rounds of questionnaires to obtain expert opinions on the proposed AIS conceptual model. The iterative process aimed to refine the conceptual model, overcome the challenges of information overload, and ensure that the system's functions are consistent with expert recommendations. These rounds resulted in consensus on several key aspects of the AIS and provided valuable insights for its development and implementation.

Spreading information overload

Experts repeatedly reported information overload and highlighted its importance as a critical issue that needs to be addressed. Digital notifications and frequent context switching have been identified as sources of distraction, negatively impacting productivity and highlighting the need for effective management strategies.

Support for adaptive systems

There was a strong consensus that an AIS had the potential to increase productivity by reducing distractions and effectively managing information. Experts emphasized the importance of an AIS that adapts to individual user behavior, preferences and context changes and provides personalized management suggestions and configurations.

Key features and functions

Experts identified and refined several important features and functions of the AIS:

- Automated Tagging: Widely supported (91%), automated tagging based on content analysis was seen as beneficial for enhancing information retrieval and organization.
- Integration with Existing Tools: Prioritized integration with personal email clients (100%), calendar applications (82%), and task management tools (45%) to streamline information management.
- Delegating decisions to an AIS scheduling and calendar management (91%), email filtering and responses (82%), social media management (54.5%), task prioritization (100%).
- AI-Driven Prioritization: Using AI to prioritize information based on urgency and context was recommended to manage high-priority information effectively.
- Customizable Notifications: Suppressing notifications during focus times, summarizing information at intervals, and allowing user-customizable notification settings were highlighted as effective strategies for minimizing distractions.

Privacy and security

The importance of implementing robust data protection and security measures was strongly emphasized. Experts emphasized the need for encryption, strict access controls, regular audits and transparency about data usage to ensure user trust and protect sensitive information.

User control and convenience through automation

Retaining user control over automated decisions was deemed crucial. Experts preferred complete control over system decisions with the ability to override and customize actions. While there was some variability in comfort levels, the majority were at least somewhat comfortable with the AIS making routine or low-risk decisions.

The consensus across all three rounds highlights the importance of addressing information overload with an adaptive system that includes key features such as task prioritization, content grouping, automated tagging, integration with existing tools, AI-driven prioritization and customizable notifications. Robust security measures and user control over automated decisions are also important components. These insights provide a solid foundation for the AIS conceptual model and guide its development to effectively meet user needs and increase productivity.

6.4. Conceptual model

The conceptual model diagram of AIS in Personal Information Management represents various components and their interactions intended to enable efficient management and retrieval of information (see Fig. 6).

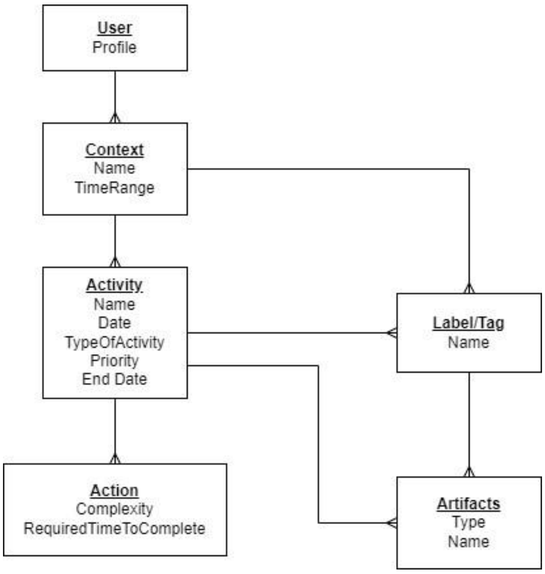

Figure 5. Conceptual model diagram

User: At the center of this model is the user, characterized by a profile that contains user-specific information. This profile influences the different contexts in which the user operates.

Contexts are defined by their name and time range, which indicate the specific situation or environment (e.g. work or personal) and the time period in which the context is relevant. Contexts are directly linked to the user, indicating that different users may have different contexts based on their profiles. Activities take place within these specific contexts and show the relationship between the context and the actions taken by the user.

An activity is nested in contexts and is linked to labels/tags and actions. Actions, on the other hand, represent the steps or tasks required to complete the activity. Each action is characterized by its complexity and RequiredTimeToComplete, which estimate the difficulty and time required to complete the task.

Labels/Tags are essential for organizing activities and artifacts. This categorization makes it easy to locate activities and artifacts and ensures that users can quickly find the information they need.

Artifacts represent different types of documents or files associated with activities. Each artifact is defined by its type (e.g. a document or an image) and its name. Artifacts are linked to both activities and labels/tags. This dual mapping means that certain documents or files are relevant to specific activities and are categorized for easy access.

6.5. Simulation development

The simulation process models the adaptive behavior of the AIS and shows how it interacts with user activities, categorizes and prioritizes tasks, and automates decision making when necessary. This simulation provides insight into the effectiveness of AIS in mitigating information overload and streamlining information management tasks.

General simulation parameters

User reading speed – parameter define user individual characteristics, that impacts on speed how fast user can read and process content. This criteria stronger participate in activity process review and simulates user reading behavior. In the model has been used average human reading speed – 238 (Rayner et al., 2016) words per minute, by modifying it will impact on the AIS activities planning.

Activity type – in the simulation consist of 4 activity types:

- News feed – defines all information that relates and incoming as a news.
- Mobile notification – activity describes any type of information that comes to user as notification like: new email, application notifications etc.
- Task – this activity describes user main task, that is coming as a regular work. In the simulation considered user tasks based on dataset analysis.
- Email – described user incoming emails.

All activities except tasks distributed between work and personal context in ratio – 75% activities about the work and 25% - personal. Tasks have been created only in work context.

Task activities - distributed across 3 types:

- Assign ticket seriousness – user review ticket and apply criticality on the ticket
- Resolve the ticket – user review and close the task as accomplished
- Take in charge ticket – when user actively working on the ticket.

Tasks distributed according to the dataset analysis and should be assign average a 1 ticket per day, and can be minimum 1 and maximum 12 tickets per day. Then should be 1 resolved ticket per day with 1 minimum number and 10 max and “take in charge ticket” average 2 per day and min 1 and maximum 16 tickets.

Every task has been distributed according to criticality. There has been identified that tickets have 3 types of ticket priority. Based on the analysis those has been distributed accordingly (see Table 1):

Table 1.

Tickets criticality distribution

Criticality name	**Distribution**	**Task duration (days)**
Normal	0.5472	7
Important	0.3052	5
Critical	0.1476	2

In the simulation, users engage in both work-related and personal activities, which include emails, news, and notifications. Users receive an average of 120 activities daily: 15 news items, 64 notifications, and about 5 tasks, with the latter consuming roughly 7 hours of the day, leaving approximately one hour for reading emails and news. Activity distribution is as follows: news feeds under 15%, emails at 55%, and notifications at 40%.

The simulation spans 14 continuous workdays from 8:00 AM to 5:00 PM, distributing tasks primarily from 8:00 AM to 2:00 PM, peaking at 9:00 AM.

Simulation flowchart

The simulation process begins with the arrival of an activity that represents an information item or a task that requires the user's attention. The AIS assesses whether it is capable and able to handle the activity autonomously. When AIS is enabled, the activity is routed to AIS where the activity can be immediately processed and placed in a queue or deferred to the user for manual processing. The simulation workflow captures these interactions and illustrates the logical flow of activities through the AIS-enabled system.

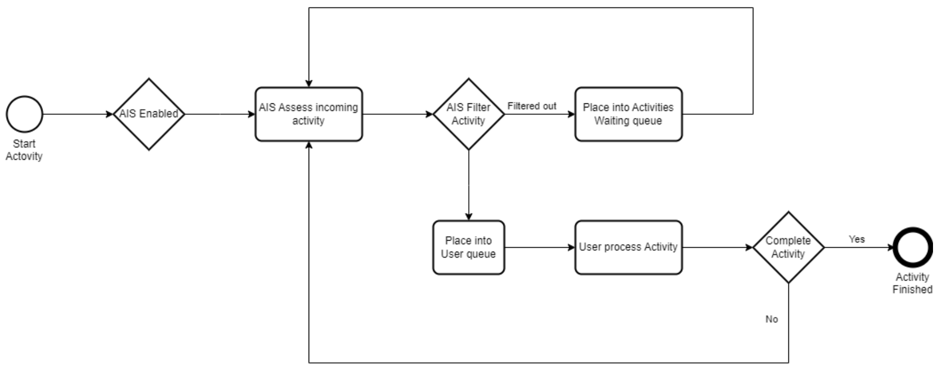

Figure 6. Simulation flowchart

The flowchart (see Figure 6) details the workflow of the AIS simulated in Anylogic. When a new Activity the system first checks if AIS is enabled. If so, AIS processes the task by categorizing and prioritizing it according to preset rules and preferences. Tasks not immediately processed are moved to a AIS waiting queue, until they can be addressed to the user. The user interacts with tasks in the processing stage, and if a task isn't completed— due to an interruption—it's cycled back to the queue. Successfully completed tasks are then marked as finished and removed from the workflow.

The Activity agent in the simulation represents the various tasks and information items that the user needs to process. Each Activity agent contains multiple parameters that define its characteristics, and the actions required for its completion. This section describes the parameters and their roles in simulating the dynamics of information management within the AIS.

Activity

In the simulation, activities were defined by multiple parameters to reflect realistic scenarios. Context distinguishes between "work" and "personal" activities, influencing prioritization. Activities contained information about device whether the activity originated from a laptop or smartphone. Importance, categorized as low, normal, or high, is based on predefined expert rules.

Every activity has a number of actions parameter, that specifies the complexity of activities, ranging from 1 to 5 actions, while RemainingTimeList and RemainingTime track the time required to complete actions and tasks. Activities are timestamped with start date and end date to aid scheduling, and artifacts (e.g., attachments) influence action complexity.

The simulation also includes parameters for interruptions to track context switching and recovery.

User behavior modeling

The user agent in the simulation mimics user interactions with activities. It starts in an Idle state, where no activities are engaged, and transitions to a Ready state when prepared to accept new tasks. If there are pending activities in the queue, it moves to Review Activity state, where it may simulate a device or context switch, introducing delays ranging from 30 to 180 seconds to represent distractions from incoming notifications. Additional delays of 30 to 60 seconds simulate internal distractions when switching between applications.

If interrupted, resuming to a previous activity might take 900 to 1200 seconds for the user to reacquaint themselves with the task, based on prior research. Following the review, the user continue to working on Activity. If an ongoing activity is of lower priority, it is swapped for a new, higher-priority activity. Within this state, the user processes necessary actions to complete the activity. Once completed, the user entered the Free state, indicating readiness to tackle the next activity or return to waiting for new tasks.

Simulation execution

The current simulation models the daily activities of an office worker over a 14-day period with working hours from 8:00 till 17:00. Each working day, the user receives between 121 and 133 activities, including emails and notifications. This range is based on research by Vengagge (2023) and Acer (2015) and reflects the typical information load of office workers. The simulation considered that users receive activities in proportion to 25% personal activities and then 75% work-related activities.

To accurately represent the variety of information found, activities are categorized into two contexts: work-related and personal. This distinction simulates the different types of activities users might be exposed to throughout the day and provides a comprehensive overview of professional and personal information management.

Activity generation schedule

The simulation is designed to mirror the natural distribution of activities throughout a typical day. Work-related activities are concentrated during standard office hours, from 8:00 a.m. to 5:00 p.m., reflecting real-world professional communication patterns. Conversely, personal activities are scheduled primarily outside of work hours, continuing into the evening. This scheduling ensures that the simulation realistically captures the flow of work and personal tasks. The activities are delivered to users through devices such as laptops and smartphones. In the simulation model, users can process only one activity at a time, maintaining a focused workflow that simulates real-life task management.

Logic of the AIS Regulation

AIS uses a rule-based approach to filter and prioritize tasks in the simulation. While advanced techniques like dynamic classification are not implemented, activities are assigned predefined importance labels that guide their prioritization. If an activity lacks a scheduled start date, the system calculates one by subtracting the estimated time required to complete the task from its deadline. This ensures that tasks are processed within their specified timeframe.

Priority Calculation

The AIS assigns priorities to tasks based on their urgency and scheduled dates. For tasks with future start and end dates, they are added to a waiting list, provided the list contains no more than 50 activities. If a task is due today or its execution is overdue, its priority increases proportionally to the delay, ensuring that critical tasks are addressed promptly. Overdue activities are marked as "disturbed," signaling their critical status and need for immediate attention. This prioritization system enables the AIS to manage tasks effectively, focusing on the most urgent and important activities.

Device Context and Activity Status

To minimize cognitive load, all activities are handled within a single device context, ensuring users operate solely on their laptops. This approach avoids the distraction of switching between devices, streamlining task management. Once priorities are calculated, the AIS updates the status of each activity and processes them according to urgency and relevance. This mechanism allows the system to dynamically adapt to changing workloads, minimizing delays and enhancing productivity.

6.6. Data analysis and validation

The efficacy of the Adaptive Information System (AIS) was rigorously tested through a comprehensive simulation campaign using AnyLogic software version 8.9.0. A total of 50 simulation runs were conducted, equally split between scenarios with AIS enabled (25 runs) and disabled (25 runs), generating nearly equal activities in each state—47,189 activities with AIS disabled and 47,197 with it enabled, totaling 92,513 activities across all simulations.

The simulations were designed to mimic real-world workflows, distributing activities between personal (25%) and work-related (75%) tasks to reflect typical usage scenarios. The activity distribution was meticulously tracked, with personal activities comprising 4,670 emails, 2,320 news items, and 4,643 mobile notifications, while work-related activities included more complex tasks such as 221 task assignments, 455 task resolutions, and 655 task charges.

To simulate a typical day's information flow, activities were generated on a schedule from 8 AM to 5 PM, peaking during midday hours. For example, from 8-9 AM, 3 activities were generated, increasing to 9 by 10 AM, and peaking at 25 activities between 12-1 PM, before tapering off in the late afternoon.

Moreover, the nature and intensity of activities varied, with each type of activity requiring a different number of actions, influenced by the complexity of the task. Notably, tasks were programmed to require more actions due to their longer average duration, aligning with the protocol that divided the total execution time of tasks by an 8-minute interval per action. Overall, the average time spent on activity actions was approximately 18,268.82 seconds (about 5 hours) per day.

Extending the validation, several simulation scenarios were tested over a 30-day period to ensure the AIS's robustness and reliability over extended operational periods. These extended simulations confirmed that the AIS rules functioned as expected, without any degradation in performance, and all required activity parameters were consistently met across varied metrics.

Critically, the effectiveness of the AIS in managing information overload was quantitatively assessed using the McNemar test, comparing the binary responses of overload occurrence between AIS-enabled and disabled states. The results were striking:

With AIS Enabled: 0 occurrence of overload.

With AIS Disabled: 5,730 occurrences recorded.

This statistical analysis showed a dramatic reduction in information overload cases with the activation of AIS, substantiated by a chi-squared statistic of 5729.8 and a negligible p-value, indicating a highly significant improvement in managing information flow and reducing overload.

Comprehensive data validation underscores that the AIS not only performs effectively under typical usage conditions but also maintains its efficacy in extended and varied operational scenarios. This robust performance highlights the system's potential to significantly enhance productivity and decision-making by efficiently managing and prioritizing tasks, thereby reducing the cognitive load on users.

7. Results

In the simulations, both scenarios (with and without AIS) were executed with a similar total number of activities, with 47189 and 47197 respectively. However, the difference in the outcomes of these activities is significant. With AIS intervention, nearly all task activities that are started are also finished, with 0 delayed out of 6528 activities being completed per round. In stark contrast, without AIS intervention of the 6528 task activities delayed (see Table 2).

Table 2.

Simulation results

AIS status	Created activities	Finished activities	Interrupted activities	Delayed activities
Disabled AIS	47189	24159	47189	6528
Enabled AIS	47197	26817	0	0

One of the most striking differences between the two scenarios is the number of interruptions. The AIS effectively eliminates interruptions during activity processing, with zero interruptions recorded per round. Conversely, without AIS, there are a significant number of interruptions, averaging 2109 per round. This highlights the AIS's capability to provide a more focused and uninterrupted workflow for the user.

Moreover, the AIS reduces the number of delayed activities. There were no activities that were delayed per round with AIS intervention, whereas, without AIS, there are 6528 delayed activities. This indicates that the AIS not only helps in managing activities more efficiently but also ensures that they are completed on time.

The AIS significantly improves task completion rates and reduces interruptions, highlighting its effectiveness in managing information overload and enhancing user productivity. There were 5730 observations of information overload recorded prior to AIS disable, but there were none when AIS was turned on. These results demonstrate that the AIS significantly enhances efficiency by ensuring that almost all started activities are completed with minimal delays and no interruptions. This leads to higher productivity as the AIS reduces the cognitive load on the user, minimizes delays, and eliminates interruptions, allowing for better time management and task performance.

8. Discussion

The design of the conceptual model is grounded in understanding how people manage personal information in a digital environment, incorporating user-centered design, context support, cross-platform functionality, privacy and security, advanced search and retrieval, automated organization, and scalability. The central element of the conceptual model of the AIS is the centralization of incoming and outgoing information, which optimizes processes and reduces complexity for the user.

The AIS conceptual model includes several components: the user profile, contexts, activities, labels/tags, and artifacts. The user profile influences various contexts, in which activities occur, while labels/tags and artifacts help organize and retrieve information efficiently. This model emphasizes how users interact with contexts, manage activities, perform actions, and utilize artifacts, highlighting the importance of labels/tags in organizing information.

The Delphi method was implemented to validate the AIS conceptual model through expert assessments. The consensus across all three validation rounds underscores the importance of addressing information overload with an adaptive system. It incorporates automated tagging, integration with existing tools, AI-driven prioritization, and customizable notifications.

The simulation development process in AnyLogic models the adaptive behavior of the AIS, demonstrating its interactions with user activities, task categorization, prioritization, and decision-making automation. Activities are processed through a workflow that includes decision points for AIS processing, waiting queues, and user interactions. The simulation results highlight the effectiveness of the AIS in managing activities compared to the scenario without AIS intervention.

The findings validate the hypothesis that AIS reduces information overload. The system's ability to adapt to user behavior and preferences is crucial in managing cognitive load. The research questions are addressed through the AIS model development and validation, to provide actionable insights into effective strategies for reducing information overload.

9. Conclusion

This study presents a novel, validated conceptual model for an AIS that effectively addresses the pressing challenge of information overload in the digital age. The basis of the AIS is its ability to adapt dynamically to individual user preferences and contexts, providing a personalized approach to information management. The study demonstrates the system's potential to significantly reduce cognitive load and improve performance using a robust multi-method approach that combines expert review and modeling. The AIS aims to simplify personal information management to improve decision-making, reduce stress, and boost productivity in both personal and professional contexts. Therefore, AIS in today's digital environment where information overload is a common problem will be a useful tool. Future research should focus on implementing AIS in the real world, examining how it integrates with current digital systems, and assessing its long-term impact on user performance and behavior. Exploring the integration of more advanced machine learning algorithms is also highly necessary. Implementing these improvements will enable the system to anticipate users' information needs and adapt to changes, improving overall system management.

Further research should include quantitative analyses demonstrating the impact of AIS on cognitive load and performance, as well as user feedback and case studies illustrating real-world implementations and user experiences. This will help to strengthen the AIS's validity and applicability. To give the AIS's personalized nature, ethical and privacy concerns must be addressed, to guarantee that the system strictly maintains user confidentiality and data protection guidelines.

By making progress in these areas, the AIS model has the potential to transform personal information management and establish new standards for adaptive digital technologies in the future.

Acknowledgments

The authors extend their deepest gratitude to all university colleagues whose invaluable assistance and unwavering support greatly contributed to the completion of this research article.

A heartfelt thanks are extended to Professor Irina Yatskiva for her exceptional support in the research methodology.

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Received September 10, 2024, revised January 30, 2025, accepted February 18, 2025