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# Next generation smart system: 4-layer modern organization and activity theory for a new paradigm perspective

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This research article discusses a new paradigm in smart system development using the 4-layer framework and activity theory from the perspectives of ontology, epistemology, and axiology. The study aims to understand how this paradigm can influence the development of smart systems and provide insights into its theoretical and practical implications. The 4-layer modern system comprises instrumentation, information systems, business intelligence, and gamification, which are the core components of a smart system. Each layer plays a crucial role in data collection, information processing, business analysis, and gamification implementation at the top layer. The integration of these layers forms a solid foundation for the development of efficient and innovative smart systems. In addition, activity theory is utilized to analyze the interactions among users, technology, and the environment within the context of smart systems. From an ontology standpoint, this research views smart systems as complex socio-technical entities involving human, technological, and process aspects. In terms of epistemology, a multidisciplinary approach is employed to combine knowledge from areas such as computer science, information systems, and human-computer interaction. In the realm of axiology, this study recognizes the ethical values and social implications that must be considered in the development and implementation of smart systems. By integrating the new smart system paradigm using the 4-layer modern systems and activity theory, this research contributes to the understanding of the dynamics and development potential of smart systems. The results of this study can provide guidance for practitioners, researchers, and decision-makers in developing more effective, efficient, and user-oriented smart systems in various contexts.

**Key words:** new paradigm, smart system, 4-layer modern system, activity theory, ontology, epistemology, axiology



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## 1. Introduction

In the era of rapid information and communication technology development, smart systems have become the focus in various sectors. Smart systems, supported by artificial intelligence and related technologies, promise great potential to improve efficiency, productivity, and service quality in various fields such as industry, transportation [9, 53], health [52], manufacturing [42], education, conservation [7, 8, 51], arts [2], and others. However, with the increasing complexity of smart systems being developed, new challenges arise in their development, implementation, and use. Therefore, a new paradigm is needed through a holistic and integrated approach that includes ontology, epistemology, axiology, 4-layer, and activity theory, capable of overcoming these problems and advancing the development of smart systems.

In the context of smart system development, several main problems need to be addressed. Firstly, there is increased complexity in terms of design, component integration, and data usage. Technological advancements have resulted in increasingly complex smart systems, necessitating new approaches to overcome the challenges posed by this complexity. Secondly, in developing the next generation of smart systems, there are still unresolved issues in developing a robust approach to understanding and representing the complex realities of smart systems. Thirdly, methods and algorithms are needed that can acquire new knowledge and address complex challenges. Fourthly, the next generation of smart systems must operate with integrity, transparency, and ethical awareness, with user involvement being a key factor in their success within optimal socio-cultural contexts. Integrating smart systems and activity theory is necessary to improve the context of the subject as a human and to leverage the potential of artificial intelligence. Additionally, attention must be given to the implications of ontology, epistemology, and axiology in the development of smart systems to ensure that they are not only technically effective but also consider views of reality, sources of knowledge, and ethical values.

The main objective of this research is to gain a better understanding of the ontology, epistemology, and axiology underlying the next generation of smart systems and to apply the 4-layer and activity theory in system development that focuses on user needs. Furthermore, this research aims to explore new solutions to overcome the challenges encountered in the development of smart systems. By proposing a new paradigm in the form of a new smart system paradigm with 4-layer and activity theory, incorporating ontology, epistemology, and axiology perspectives, this research aims to optimize the development of smart systems. Additionally, this study seeks to broaden the understanding of smart system development by considering socio-technical aspects and related theoretical implications. The success of this research will provide a valuable contribution to practitioners, researchers, and decision-makers in optimizing the development and application of smart systems in various sectors.

Based on the background and issues raised, this research will attempt to answer the following research questions: how can the new smart system paradigm with 4-layer modern systems and activity theory, incorporating ontology, epistemology, and axiology perspectives, overcome the increasing complexity of smart systems, improve efficiency in data collection and processing, increase user involvement, and consider aspects of ontology, epistemology, and axiology in the development of smart systems? By addressing these research questions, this research aims to make a significant contribution to the development of a new paradigm in smart system development and advance the field to a higher level.

## 2. Related work

### 2.1. System, smartness and smart system

In reference to [42], there is a definition of a system described by [34], stating that a system is a collection of elements or components that are interrelated and influence each other through certain relationships, working together to achieve specific goals. According to D. Anguita [43], the term "smart" refers to the ability to effectively interact and communicate with others, as well as the ability to build and maintain positive and beneficial relationships. In this case, a smart system is considered as an implementation of information technology that can enhance performance and effectiveness in an organizational or business environment. Smart systems are capable of monitoring, making decisions, and controlling business systems, thereby improving efficiency, quality, and speed of business performance [23]. The terminology "smart system" is defined as a system that can obtain information from the environment or its users, process this information, and then interact with the environment or users based on the results of this information processing [43]. These systems leverage advanced technologies such as internet of things, big data, and artificial intelligence [6] and encompass a series of cyber-physical system technologies that integrate computing, network, and physical systems to create a feedback system [16, 69]. Cyber-physical system represents a combination of several systems with different properties, aiming to control physical processes and adapt to real-time conditions [1]. Consequently, cyber-physical system can autonomously monitor and control itself [21], acquiring in-depth knowledge to manage the environment [32, 69].

While research related to smart systems has been conducted in recent years towards a smarter next generation system, there are still significant research gaps, or a lack of research related to the activities of stakeholders including managers, engineers, and customers [42]. Additionally, besides the key role within an organization, there is a need for an architecture that can describe human goals in the context of individuals and groups, as well as their social relationships. Current research on smart cyber-physical systems [19] should delve deeper into these aspects, establishing a level or reference point to gauge intelligence in these three areas.

There is no standardized terminology for “smart system”. Despite its widespread usage, differing views and interpretations persist. Therefore, it is crucial to emphasize the development of an architecture that can establish clear and consistent characteristics, facilitating a better understanding of smart systems and enabling effective communication among stakeholders.

In the present era, the advancement of the next smart system beyond its predecessor lies in surpassing human limitations, particularly in intelligence. Intelligence encompasses not only intellectual capabilities but also interpersonal skills, communication skills, integrity, and motivation. Limitations in human intelligence can impede an organization’s goal attainment if not properly managed. Such limitations can result in difficulties making sound decisions, a lack of innovation, and an inability to adapt to environmental changes. Overcoming these limitations is vital for organizations to enhance their efficiency and effectiveness. One notable limitation is the scarcity of individuals who meet specific intelligence standards. While some individuals possess intelligence within an organization, knowledge transfer to others is often limited, and many individuals lack sufficient intelligence. The impact of human limitations related to intelligence within organizations can be significant. These limitations can hinder an organization’s ability to quickly adapt to changing environments and markets, address emerging challenges and risks, and make informed decisions. Constraints can also impede an organization’s ability to create, combine, and leverage the knowledge and expertise necessary to achieve its goals and vision. Furthermore, limitations in intelligence can affect the quality and productivity of work, as well as restrict individuals’ ability to develop and contribute optimally within the organization. Therefore, organizations must explore ways to overcome these limitations, including the development of existing human intelligence. Additionally, finding ways to amplify intelligence on a larger scale is crucial. One approach to addressing human limitations in intelligence is by developing artificial intelligence to perform specific tasks. In an organizational context, the use of artificial intelligence can enhance efficiency, productivity, and quality in executing complex tasks that require extensive and intricate data analysis. The current context of technological development and its impact on human civilization underscore the emergence of a distinct societal landscape, particularly within the realm of human progress.

### 2.2. Basic concept of people, process and technology

Currently, various fields face a multitude of complex problems that were previously unresolved. This has prompted organizations worldwide to undergo a paradigm shift and make significant changes to harness the potential of human civilization and tackle these increasingly intricate challenges. The digital technology landscape, along with the interplay of people and processes, has played a pivotal role in driving these transformative shifts [37]. Notably, the concept of technological singularity, as explored by [29] and [49], further emphasizes the need for rapid adaptations in individual and organizational activities to address various solutions and requirements. The singularity positions that there will be a point where the potential of human civilization surpasses its ability to solve complex problems. Consequently, it is crucial to recognize that humans possess the capacity to tackle these exceedingly intricate problems that were previously unresolved. In other parts of the world, it is suspected that technology has already made significant strides in addressing complex problems. Nations capable of tackling these challenges successfully are those that effectively harmonize people, processes, and technology within a systematic framework, utilizing these three components to overcome diverse problems. The desired harmonization entails leveraging the potential of cutting-edge technology and processes, with individuals prepared to harness the capabilities of technology to address the problems at hand.

The concept of “people” encompasses both individuals and groups involved in a specific context, such as an organization, community, or work team. It encompasses social interaction, individual abilities, communication, leadership, and collaboration among people. “Process” refers to a series of steps or activities performed to achieve a specific goal. Processes can be applied in various contexts, including business, manufacturing, product development, or project management. The purpose of processes is to enhance efficiency, minimize errors, and achieve desired outcomes. “Technology” includes knowledge, tools, and methods used to create, operate, and utilize systems or tools to solve problems or achieve goals (Fig. 1). Technology can encompass information technology, communication technology, manufacturing technology, or various other technologies used in different fields. Often, “people”, “process”, and “technology” are interconnected and mutually influential. People utilize technology and engage in processes to accomplish their objectives, while processes can be influenced by the people and technology involved. Examples of the concept of intelligence within the framework of people, process, and technology in the present context include: people’s intelligence can be enhanced by providing employee training, developing interpersonal skills, and improving the quality of work life.

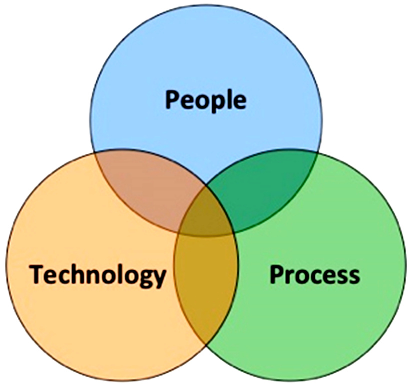


Figure 1: People, process, technology [68]

- People's intelligence can be enhanced by providing employee training, developing interpersonal skills, and improving the quality of work life.
- Process intelligence can be increased by identifying and eliminating bottlenecks, leveraging the latest technology, and optimizing workflows.
- Technology intelligence can be elevated through the adoption of cutting-edge technology and the implementation of more efficient and integrated application development approaches.

### 2.3. Activity theory

#### 2.3.1. Object-oriented

In activity theory, objects are not only physical but also mental or abstract in nature, such as goals, values, or concepts.

#### 2.3.2. Activity hierarchy structure

The hierarchy of activities, actions, and operations in activity theory is an important concept that allows us to understand the structure and complexity of human activity. These hierarchical levels make it possible to divide complex activities into smaller, more organized parts that are easier to learn and understand. In addition, this hierarchical concept also makes it possible to identify and understand how large and complex activities can be broken down into simpler, more organized actions.

#### 2.3.3. Internalization/externalization

This sentence implies that the internalization of the cultural sign system produced by society brings about a transformation of behavior and forms a bridge between the initial and later forms of individual development. In the context of

Vygotsky's theory of cognitive development, internalization or internalization refers to the process by which individuals internalize concepts and knowledge through social interactions and their personal experiences. This process allows individuals to acquire skills, knowledge, and cultural values that are absorbed through social interaction and form the basis of their cognitive development. This internalization of cultural sign systems plays an important role in shaping individual behavior and links the early and later stages of individual development.

#### 2.3.4. Mediation

In order to achieve significant goals, humans use various mediating objects or tools that reflect the experiences of others who have gone before them. These tools shape human activity in such a way as to enable the accumulation and transmission of social knowledge.

#### 2.3.5. Transformation

The development of human activity undergoes constant transformation. Therefore, transformation analysis is very important for understanding how human activities change and develop over time.

In Human Computer Interaction (HCI) research, the activity theoretical perspective is mainly related to tool mediation, namely how technology is adapted by individuals and groups, how individual and collective activities are changed as a result of the appropriation of tools, and how interactive tool design can have a positive impact on human activity. Without human activity, a system of social relations would not exist and would not have a structure, because human activity is what shapes and modifies the structure through a complex process of transformation and interaction with other elements in the system.

Engeström [17] broadens the scope of activity theory in his theory by adding components such as tools or instruments, rules or regulations, community, and division of labor. This is done to enrich our understanding of how the interaction between subjects and objects in an activity occurs, including the roles played by tools or instruments, rules or regulations that govern activities, community as the social environment where activities occur, and the division of labor that influences how activities are carried out collectively. Thus, activity theory does not only focus on the relationship between subject and object, but also pays attention to the interactions between the various components in an activity as an interrelated system. The activity theory – Activity Triangle Model developed by Engeström et al. [17] (Fig. 2) is very useful for analyzing and understanding the complexity of human activity in various contexts, such as organizations, industry, and education. This model has become a practical theoretical framework that is widely used in system analysis and evaluation and helps in developing effective frameworks to improve the performance and efficiency of existing systems.

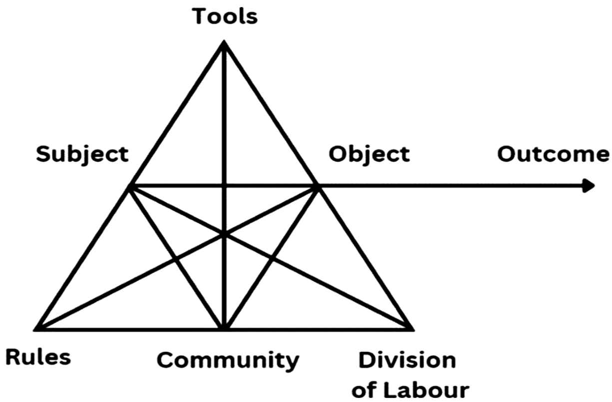


Figure 2: he triangular activity model presented by Engeström

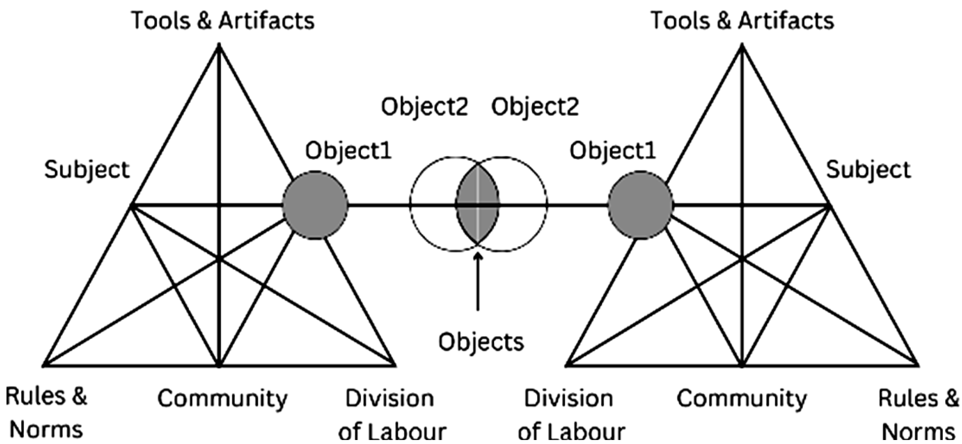


Figure 3: Activity theory of interacting the third gen [33]

The descriptinon of the interacting activity theory (Fig. 3) is as follows:

**Objects (objectives)**

According to activity theory, the object is a fundamental and important concept because it relates to fulfilling needs. An activity without an object holds no significant meaning. In the context of system activity, objects are the main focus, interconnected with other units of analysis. In the current era, it is important to develop an object-oriented activity theory perspective with clear and substantial goals to understand activities in a system holistically and integrated [65]. [39] also emphasizes that the object is a series of intentional relationships carried out to provide motivation and direction to system activities, aiming to achieve desired needs and satisfactions.

### Subject

Subjects are identified as individual entities or groups of people involved in an activity. Usually, interactions between subjects are strengthened by units connected by the tools or artifacts used in carrying out these activities. In the contemporary era, a more in-depth explanation regarding the definition of the subject in the context of a complex system is needed to clarify the role of the object in providing direction or instructions for the subject in carrying out activities. According to [4], in complex activities, objects must be interpreted by a group of individuals in their implementation.

### Mediating artifacts

To understand human activity, artifacts are needed to respond to the needs and requirements of an activity. Artifacts can help the subject take practical actions and provide psychological support for mental actions [35]. The reciprocal relationship between the subject or actor and the activity object is mediated by the "tool", which has a historical development closely tied to the subject and the object. "Tools" empower subjects in the transformation process by incorporating experiences, skills collected over time, and crystallized expertise [10]. Each activity usually involves various artifacts such as instruments, signs, procedures, machines, methodologies, regulations, work forms, and others. The essence of artifacts is to act as a means of mediation.

The relationship between the elements in an ordinary activity is not direct but mediated. For example, there is a subject/actor connected to a mediated object. The artifact itself has been created and transformed during the development of the activity and carries a certain cultural and historical heritage [70].

### Community/Society

The community consists of various individuals and sub-groups that share a common object [72]. The community plays a supporting role in directing the subject towards the object. Thus, the community is part of the support system between subjects, objects, and tools. In general, theory forms a community through shared concepts. While achieving perfect communal unity in vocabulary and concepts is unlikely (and not desired), without some theoretical connective tissue, effective communication among individuals becomes challenging.

### Division of work

The division of labor refers to the hierarchical structure of activities and how actions are divided and distributed among members of society. It defines various roles and responsibilities for community members in an activity [12, 49].

### *Rules*

According to [17, 61], rules mediate the relationship between the subject and the community, subject and object, and object and community. They are related to laws and conventions that activity participants must comply with in carrying out their roles.

The emergence of HCI largely results from the application of certain theoretical approaches, such as information processing psychology [57], psychology related to gamification [56], analysis [60], interactive system design [45], and even for the current era, areas related to cyber physical systems [42] and artificial intelligence [76]. Several influential HCI research contributions have contributed to the development of theories both theoretically and practically [10, 26, 46, 54, 64]. Exploring a theory from HCI requires basic information from everyday culture, particularly from a psychological perspective derived from the field's history. However, realizing this is challenging, hindering the development of a general theory [60]. The development of the second wave of theory for HCI occurred around 2006 [55, 67], and it defined HCI in a more modern second wave, similar to [53].

## 2.4. Organization and intelligence systems

An organization is an entity or group composed of individuals who work together to achieve common goals [25]. Organizational goals can vary, including achieving profits, providing public services, or attaining social objectives. One well-known approach is the theory of management by objectives, which Peter Drucker developed in 1954. This approach emphasizes the importance of clear and measurable goals in achieving effective performance within organizations. In this approach, management and employees collaboratively set organizational goals and objectives. Additionally, strategic management theory highlights the significance of goals and objectives in achieving long-term organizational success. In this approach, the organization must establish a long-term vision and set strategic goals that align with that vision. These strategic objectives then serve as the basis for designing strategies and allocating organizational resources. It can be concluded that goals and objectives are at the heart of organizational activities, and their proper management is crucial for achieving optimal performance.

## 4-layer organizational system structure

The organizational system structure refers to a systematic framework or set of processes and management practices implemented by an organization to achieve its goals. This structure consists of several interconnected levels or stages that support each other in accomplishing the company's business goals.

The division of the organizational system structure into four layers is a common approach used in system development and organizational management. This division reflects the different responsibilities, roles, and decision-making levels within an organization. Although there may be variations in terminology and details among different approaches or models, the division into strategic, tactical, operational, and technical layers has been widely utilized in management and systems development literature.

The organizational system structure can be divided into four layers commonly used in the context of system development. The following is the division of the four layers:

1. *Strategic layer*: This layer focuses on strategic decision-making at the top level of the organization. Here, strategic decisions are made to formulate the vision, mission, goals, and long-term direction of the organization. Activities in this layer involve organizational leaders and pertain to strategic aspects such as business development, policy setting, and market analysis.
2. *Tactical layer*: This layer involves middle management within the organization. Activities in this layer relate to tactical planning, resource management, and the implementation of organizational policies. Managers in this layer are responsible for resource allocation, team performance oversight, and ensuring the achievement of the organization's tactical objectives.
3. *Operational layer*: This layer is associated with the implementation of daily operational tasks within the organization. Activities at this layer are performed by staff and employees who carry out basic operational processes, such as production, sales, shipping, or customer service. The objective of this layer is to perform tasks with maximum efficiency and quality.
4. *Technical layer*: This layer encompasses the technology infrastructure and systems that support the organization's operations. Activities at this layer include the development, implementation, and maintenance of information technology systems, communication networks, databases, and other hardware and software. The purpose of this layer is to ensure the availability, reliability, and security of the technologies that support organizational activities.

By dividing the organizational system structure into four layers, we can gain a more detailed understanding of how human activities, decision-making, and technology utilization are integrated within the organization. This aids in designing effective systems, improving performance, and better achieving organizational goals.

In general, the organizational system structure combines four levels (Fig. 4):

- Layer 4: Strategic or organizational context, objectives and goals.
- Layer 3: Tactical or core business processes and supporting business processes.
- Layer 2: Operations/procedures.
- Layer 1: Technical/work instructions.

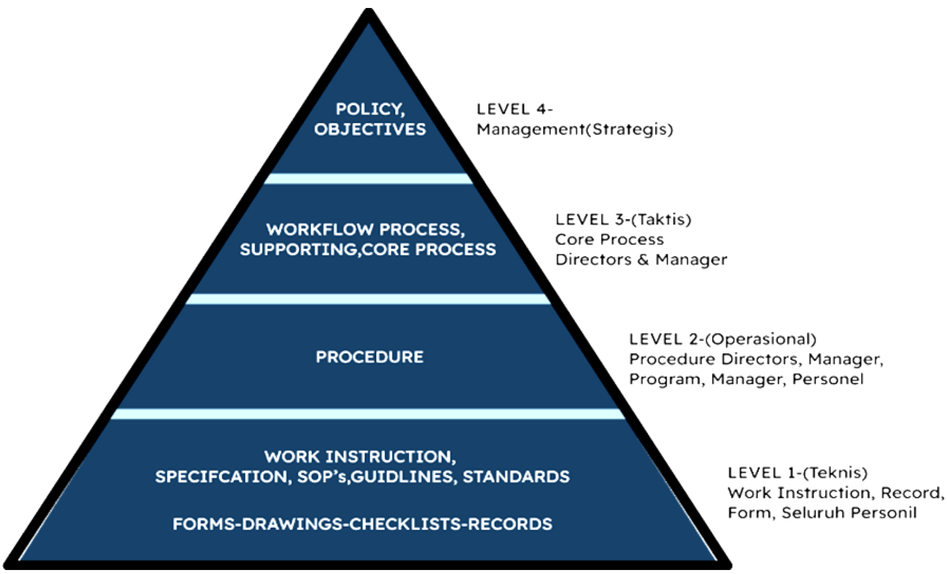


Figure 4: Organizational system structure [56–60]

These levels form a framework that assists companies in managing their business processes in an organized and systematic manner. Each level has different responsibilities and duties, but they are interrelated and support each other in achieving the company's business goals. For example, in a quality-oriented organizational system structure [62], the system is designed to lead and manage the organization, taking into account the policies, processes, procedures, and resources necessary to achieve organizational goals in terms of the quality of products or services produced, as well as meeting customer requirements and applicable regulations.

An organization that implements a management system typically manages and has a documented system to handle its information documentation. It provides a framework for organizations to improve their performance by focusing on the quality of products or services offered to customers. One example of an organizational system structure is a quality-oriented system, which usually includes requirements for designing, implementing, and maintaining a quality management system, as well as ensuring continuous improvement of the system's effectiveness. Since information must be controlled and is a significant component of a management system, especially one that is quality-oriented, it is referred to as "documented information" [62] in terms of information management.

If we examine the information documentation in the organizational system structure below, we can gain valuable insights into the organization's processes and operations.

## 2.5. Current era technology

### 2.5.1. Cyber physical system

The cyber-physical system (CPS) is a process that integrates computing, network, and physical systems to create a feedback system [16, 69]. CPS combines multiple systems with distinct properties, aiming to control physical processes and adapt to real-time conditions [1]. Utilizing artificial intelligence, CPS manages the environment by acquiring in-depth knowledge [32, 69]. CPS can be defined as a physical system that is systematically controlled or manipulated through engineering technology. It comprises a collection of computing devices that communicate with each other and interact with the physical world through sensors and actuators within the feedback loop [47]. The connection with the physical environment and processes is crucial in CPS [46]. The CPS environment model consists of an embedded system for information processing and a dynamic physical environment. The concept of CPS is an extension of the embedded system. Initially, computers functioned independently for numerical and data processing, but as their daily functions expanded, general computer usage now involves integrated software and hardware within mechanical or electrical systems designed for specific purposes. This even includes microcontroller devices integrated into embedded systems [47].

In addition, a crucial aspect in CPS design is the control of physical processes through monitoring various variables and utilizing intelligent computing. This intelligence enables CPS to make precise decisions and take appropriate actions at the right time, paving the way for the advancement of virtual, physical, and intelligence technologies into the next generation. As a result, the emergence of smart CPS or smart systems takes place. These systems are characterized by their large-scale and pervasive software-intensive nature, connecting and integrating diverse data sources, and implementing intelligent systems (Fig. 5). Consequently, they are capable of effectively managing real processes and offering a wide range of new applications and services [19, 69].

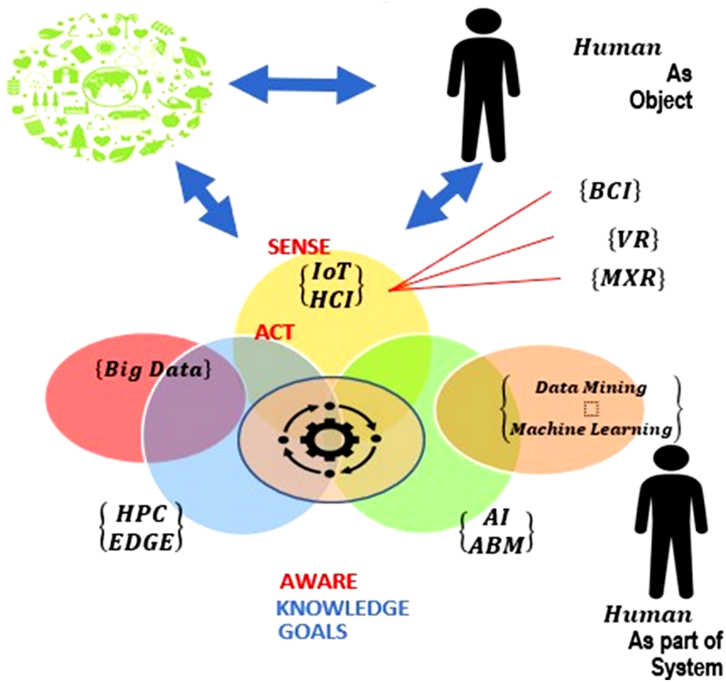


Figure 5: Interconnection of CPS components

#### 2.5.2. Smart system architecture

Smart system architecture is a system architecture comprising components such as natural language processing systems, machine learning systems, database systems, sensor data collection systems, and user interface display systems (Fig. 6). This architecture is designed to integrate diverse data types and services from various sources and perform complex data analysis to generate intelligent services. It leverages technologies like cloud computing, big data, and internet of things to provide effective and efficient smart services [70]. Although no specific architecture is defined for smart systems in the study, commonly used architectural models in smart service systems include microservices architecture, internet of things architecture, and big data architecture. The inclusion of ontology in the later developed architecture becomes essential for achieving semantic interoperability. Thus, empirical studies are necessary to understand the use of ontologies in smart systems and their potential to enhance semantic interoperability. Several crucial considerations need to be taken into account in developing an improved architecture to promote semantic interoperability between smart systems. These include the use of standardized and comprehensive ontologies to facilitate system integration, an effective method for mapping data and metadata between systems, and the implementation of an evaluation method to ensure good semantic interoperability. The development of technology that can automate the integration of ontology and metadata can enhance efficiency and minimize human errors. Lastly, the adoption of common and widely accepted semantic standards is crucial for ensuring interoperability between systems, enabling even traditionally disconnected systems to connect with others [6].

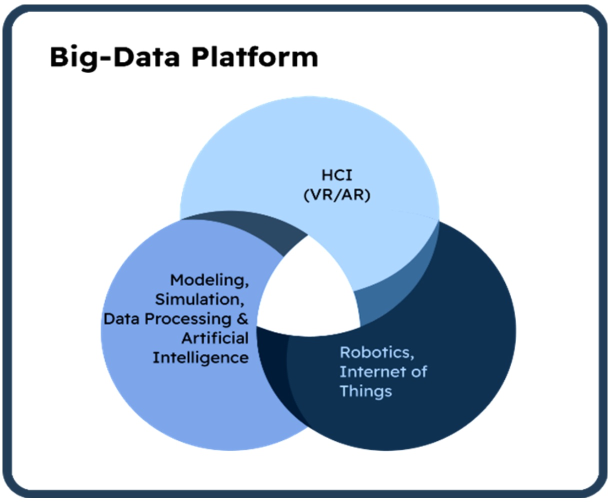


Figure 6: Modern systems in the current era

In the realm of smart system technology, such as internet of things, artificial intelligence, big data, and HCI augmented reality/virtual reality, the architecture related to system of systems becomes increasingly significant due to the interconnection and interaction of multiple systems [15]. Thus, developing a sound system of systems architecture in the context of software development is crucial. Further research can explore the complex interactions between systems within the system of systems architecture, as well as aspects like interoperability, reliability, and efficiency related to system interactions within the system of systems architecture. Additionally, it is essential to consider architectures that can interact effectively with the environment and stakeholders involved in system development and use.

To achieve long-term operational success with artificial intelligence, readiness in terms of people, processes, data, and technology is required. Hence, the smart system architecture, encompassing these four factors, can serve as a solid foundation for successful artificial intelligence implementation within organizations [68]. The discussion in this article highlights the significance of technology infrastructure, the use of artificial intelligence in information systems and business intelligence, as well as careful planning and strategies in implementing smart system architectures and achieving optimal results with artificial intelligence. It is crucial to harmonize organizational and human aspects in the context of technology adoption. The article also presents further research opportunities, such as clarifying the unit of analysis used in the research, exploring the mediating role of technology in organizational contexts, and describing artifacts and objects in relation to technology use within organizations [68].

The application of smart systems in organizations enhances business performance through the effective integration of activities and systems, improved communication, and enhanced decision-making between humans and devices [23]. However, there are opportunities for architectural development that focuses on analyzing the interactions between human activities, organizational systems, and technology within the context of smart system architecture. The role of organizational system structure in the adoption and implementation of smart system architectures should be thoroughly examined. Detailed analysis of each component in the smart system architecture and their interactions in achieving business goals and improving performance is essential for constructing future architectures.

The concepts discussed in [19] align with the principles of smart system architecture, such as technology integration, data processing, and energy management. The combination of these diverse components within an intelligent CPS system contributes to the development and understanding of smart system architectures. Further research opportunities exist to develop an architecture that connects and interacts the components within a smart system architecture.

Cloud computing enables flexible and scalable usage of computing resources on-demand over the internet. In the context of smart system architecture, cloud computing and microservices can support transaction management in enterprise application development [5,71]. The need to migrate from expensive-to-maintain legacy systems to modern architectures encourages companies to adopt cloud computing and microservices [71]. Traditional approaches like workflows may not be suitable for managing business processes in microservices systems, and existing solutions have limitations in addressing the dynamic nature of microservices location and orchestration requirements [14]. Migrations from monolithic systems to microservices have significant economic impacts and require extensive system refactoring [66].

## 3. Results and discussion

### 3.1. Relationship between process, people and technology with activity theory

In activity theory, there is a close relationship between process, people, technology, and the concept of activity. The following is an explanation of the relationship between these concepts in the context of activity theory:

1. *Activity*: Activity is the basic unit in activity theory. Activities involve human interaction with their environment to achieve certain goals. Activities involve people (people) who carry out certain actions or activities, using technology (technology) and through certain processes (process).
2. In activity theory, the concept of "people" refers to the individuals or groups involved in the activity. This theory emphasizes that human activity must be understood in a social, cultural, and historical context. Roles, motivation, knowledge, skills, and social interaction influence people's participation and interaction in these activities.
3. *Technology*: Technology plays an important role in activity theory. Technology refers to the tools or resources used by people in their activities. Technology can cover a variety of things, such as physical devices, information systems, or infrastructure used to achieve activity goals. In some contexts, in activity theory, the subject may refer to technology or non-human entities. In some situations, technology can be an active subject in activities, where technology can have the ability to interact with the environment, take action, and contribute to achieving activity goals. For example, in the context of the internet of things, connected objects or devices can act as subjects participating in activities, such as collecting and analyzing data, making decisions, or communicating with humans or other devices. In this case, the subject as technology becomes an important part of analysis and understanding in activity theory
4. *Process*: Process refers to the sequence of steps or activities carried out in an activity to achieve a certain goal. In activity theory, processes are important elements that shape the structure and dynamics of human activity. Processes can include the tasks to be completed, the flow of information, the coordination between people, and the use of technology. An understanding of processes helps identify how the interactions between people, technology, and the social environment shape activities.

In activity theory, the interactions between processes, people, and technology influence each other and shape the dynamics of human activity.

### 3.2. Technology and subject in activity theory

In the context of activity theory, technology can be equated with human subjects. This occurs when technology has an active role in activities, has the ability to interact, take action, and contribute to achieving the goals of the activity (Fig. 7). In this case, technology is considered as a subject that has agency and participates in activities similar to humans.

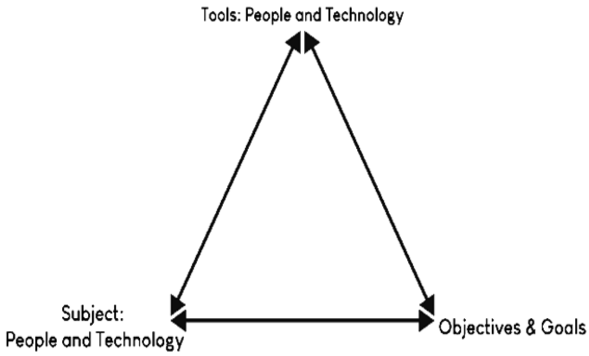


Figure 7: Technology-subject relationship in activity theory

In this perspective, technology is considered as an actor that has an important role and contribution to activities, both as a tool used by humans, and as an entity that has its own ability to interact with the environment and take action. A more holistic understanding of the subject in activity theory recognizes that technology can have a significant role in human activities and affect the way things work and the results of those activities. Activities in general according to [4], are not just human activities, but activities can be in the form of any subject, this needs to be explained clearly that in interaction with anything the subject always has a goal through the transformation of a two-way relationship between 'subject-object' in order to achieve it.

In activity theory, technology can be considered as a subject when it fulfills certain conditions. The following are some situations in which technology may be considered a subject within activity theory:

1. *Agency and ability to act*: Technology has the ability to actively take action or interact with the environment. For example, in an automation system, technology may make decisions, send signals, or interact with other devices or systems.
2. *Contribution in achieving goals*: Technology actively contributes in achieving activity goals. Technology can assist in carrying out tasks, speed up processes, produce output, or provide the necessary information.

3. *Interaction with humans and the environment*: Technology interacts with humans or other components in the environment. Technology can receive input from humans, provide feedback, or communicate with other users or systems.
4. *Influence on activity dynamics*: Technology influences the way activities are carried out or changes existing dynamics and processes. Technology can affect the flow of information, the division of tasks, the interactions between team members, or change the way things work as a whole.

In situations like the above, technology can be considered as a subject in activity theory because it has an active and significant role in the activities being carried out.

### 3.3. Organizational intelligence

In the organizational system structure is an important part of organizational intelligence, if related to how activity theory is linked to the organizational system structure, it will be described as follows in Fig. 8.

The organizational system structure, consisting of four levels, can be linked to activity theory because it helps organizations understand human activity as part of a larger system and integrated within the organizational environment.

1. Layer 4: Organizational context, objectives, goals can be associated with the subject component in activity theory, which includes individuals or groups of people who carry out activities. At this level, organizations need to understand the context and goals to focus human activities on achieving organizational goals.
2. Layer 3: Core business processes and supporting business processes can be associated with the object components in activity theory, which include the goals of human activities. Understanding the core processes and supporting processes within the organization at this level enables effective and efficient human activities to achieve organizational goals.
3. Layer 2: Can be associated with the rule component in activity theory, encompassing norms, values, and procedures that govern human activity. Organizations must understand the procedures to ensure consistency and compliance with rules in each activity.
4. Layer 1: Work instructions can be associated with the tool component in activity theory, involving the technology or instruments used in human activities. Understanding work instructions and technology at this level ensures activity effectiveness and efficiency.

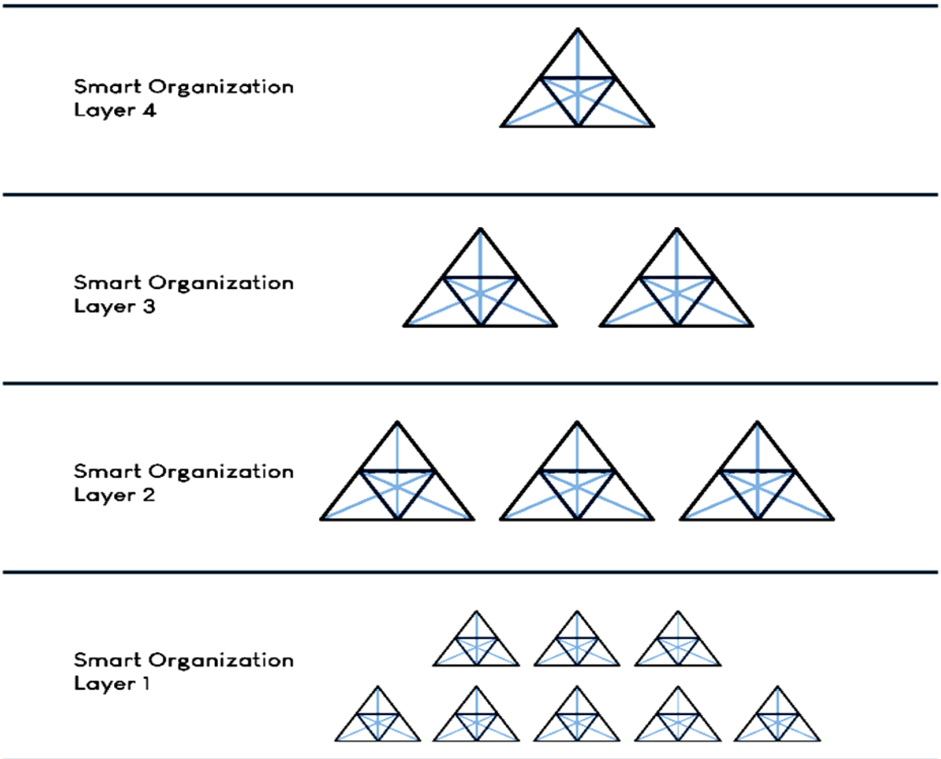


Figure 8: Relationship between organizational system structure and activity system (smart organization)

By understanding human activity as part of a larger system and integrating it within the organizational environment, organizations can develop effective and efficient manage systems to achieve their goals. This can be referred to as a smart system or organizational intelligence within the organization.

A smart organization is capable of understanding, utilizing, and developing its resources effectively and efficiently to achieve organizational goals. Integrating the organizational system structure with the social activity triangle theory enhances organizational intelligence. By understanding the structure of the organizational system and the activities carried out, organizations can identify strengths and weaknesses in achieving goals. Utilizing the social activity triangle theory, organizations can develop and improve activities related to organizational goals effectively and efficiently. This integration helps organizations improve performance and competitiveness by optimizing resource utilization.

Smart organizations can continue to evolve by employing a systematic and effective approach in managing organizational activities. If the organizational system structure and activity theory triangle are integrated with the concept of a smart organization, a smart organization can be defined as an organization that possesses the ability to understand the organizational context, goals, and strategic objectives to be achieved (Level 1). It effectively manages and optimizes core business processes and supporting business processes (Level 2), understands and optimizes the procedures implemented in carrying out these processes (Level 3), and effectively manages work instructions and operational activities (Level 4). In a smart organization, the three main elements that interact and influence one another are subjects, objects, and tools. Additionally, the supporting elements of rules, community, division of labor, and time also play a role in influencing the interactions between subjects, objects, and tools. Through this integration, smart organizations gain the ability to manage their resources effectively and efficiently, improve the quality of their products or services, and enhance overall organizational performance. This enables organizations to adapt swiftly to changing environments and face increasingly complex competition.

In the context of a modern system at the 4-layer level, the following processes are involved:

1. Layer 1: Organizations at this level are associated with databases, although a database system might not be fully developed yet. If one exists, it likely involves simple short-term memory and manually collected data when digitizing information from the real world. It is built with predefined fixed algorithms. The HCI component focuses on displaying instantaneous values, short-term trends, and determined reference values.
2. Layer 2: This level involves the information system application level, where information collected from the instrumentation application level is not only used in the moment but also systematically collected in the time and spatial domains. This allows for richer and more meaningful display and processing for users. A local database exists at this level, along with predefined algorithms that can adapt to lower-level algorithms using locally collected data. HCI focuses on monitoring and evaluating historical records and high-order statistics.
3. Level 3: This level encompasses the business intelligence system application level. It involves managing information obtained from the information system application level on a larger scale to gain deeper insights. This level involves processing massive amounts of data (big data) and utilizing explicit mathematical models, modeling concepts (modeling and simulation), and sophisticated machine learning algorithms. Portfolio databases and information structure knowledge are utilized, along with business- wide portfolio fluid algorithms that involve complex adaptations using enterprise-wide

long-term databases. HCI focuses on monitoring and evaluating business-wide parameters.

4. Level 4: At this level, the global portfolio database and information structure are managed. It involves a flexible algorithm with complex adaptation designed to achieve game objectives by manipulating lower levels and instrumentation. HCI focuses on monitoring and evaluating game objectives. This level represents the gamification system application level, where metadata values inferred from the business intelligence system application level are managed and processed to engineer user behaviors, thereby achieving specific key performance indicators (Fig. 9).

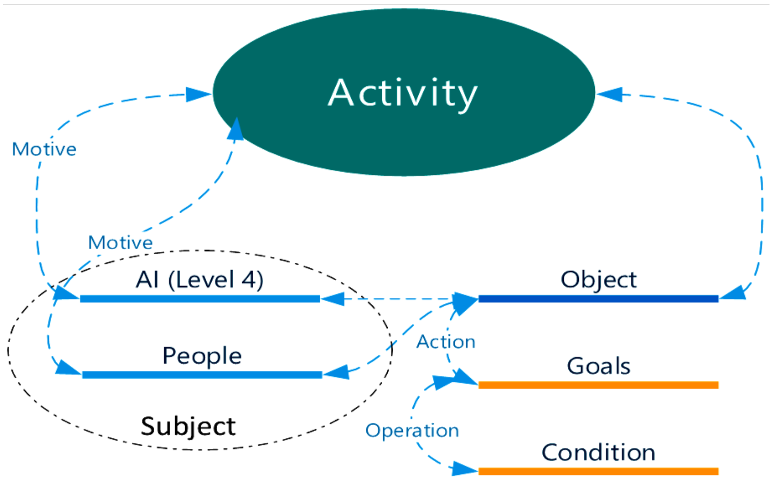


Figure 9: Example of gamification system interaction and activity

Activity theory provides a framework for understanding how humans engage with their environment through various activities and practices. This framework can also be applied to comprehend the impact of technologies like internet of things, big data, artificial intelligence, and HCI augmented reality/virtual reality on human activities and the relationship between individuals and their environment. These technologies have the potential to expand the scope of human activities and generate a wealth of new information. They enable monitoring and data collection related to human activities, leading to increased efficiency and access to more comprehensive and accurate information. Within the context of activity theory, these technologies influence the three primary components of human activity: object, subject, and environment.

Activities within a system can be regarded as interconnected units, forming complex networks through cross-hierarchies and influenced by both internal and external factors. These activities are always connected to environmental changes [33]. It is important to note that activities, as defined by [4], are not limited to human activities alone; they can take various forms involving any subject. It is crucial to emphasize that in the interaction between a subject and any entity, there is always a goal to be achieved through a transformative and reciprocal relationship between the subject and the object. Furthermore, the development and involvement of the subject can result in diverse forms of participation, potentially leading to significant shifts in our understanding of the nature of the subject [65].

The image presented encompasses several fundamental theories, including:

1. The principles of activity theory [4], which establish a connection between the subject and object levels in the activity theory [33].
2. The 4-layer modern system framework.

In system activities, the motives that create relationships between the activity and the gamification system form a complex network of interconnected nodes. Through the gamification system, unexpected and innovative solutions can emerge, connecting both internal and external nodes in a comprehensive system that may uncover previously unexplored objects. The gamification system ensures that organizational knowledge remains ingrained, even when addressing complex problems.

In this context, the object assumes a central role within the activity system, and all efforts are focused on achieving specific goals. A network of object activities is established, where humans and artificial intelligence are no longer treated as separate entities but rather as unified subjects and tools. Consequently, the system's activities revolve around the object. Regardless of the activity, an object is central, particularly when addressing problems for humans, even in cases where humans are absent at Layer 4, as artificial intelligence takes on the responsibility. Objects become the focal point for humans within the system. The system's primary focus is accomplishing goals, and humans are cared for by the system being developed, irrespective of its nature. Ultimately, the "object and goals" take center stage in the system's activity.

The purpose of analyzing activity theory in relation to the gamification system at Level 4 of the smart system is to enhance the effectiveness, efficiency, engagement, and optimal outcomes of system activities. This deeper understanding and insight into activity optimization and improvement contribute to achieving desired objectives. Additionally, the gamification system elements can increase motivation, participation, and results from various stakeholders, aligning with the defined objectives. Therefore, utilizing the gamification system is essential to enhance the experience and outcomes of relevant parties involved in specific activities.

The design and construction of smart systems, which possess high levels of intelligence, remains an ongoing challenge worldwide. Currently, the process is often carried out in an ad-hoc manner, lacking systematic and comprehensive approaches to metadata. There is a critical need for a method that enables the systematic and consistent design and construction of smart systems at all levels, from device-level to enterprise-level intelligence engineering. This approach has yet to be fully established.

To ensure the effective integration of human interaction, processes, and technology in the development of a smart system, humans must be considered an integral part of the system, guiding activities towards specific goals. However, managing activities, particularly in terms of rules and collaboration with smart systems, is of utmost importance. Humans can be compared to existing tools, effectively becoming tools themselves, as their role is to carry out activities on behalf of the subject. Nonetheless, humans should also be regarded as subjects in certain capacities (as shown in Fig. 10. It is important to clarify that in relation to cyber-physical-human systems, humans should be treated as subjects rather than tools. Similarly, CPS or artificial intelligence can also act as subjects at certain levels. The relationships between these entities should align with established rules, norms, regulations, as well as roles, duties, responsibilities, and authorities within an organization.

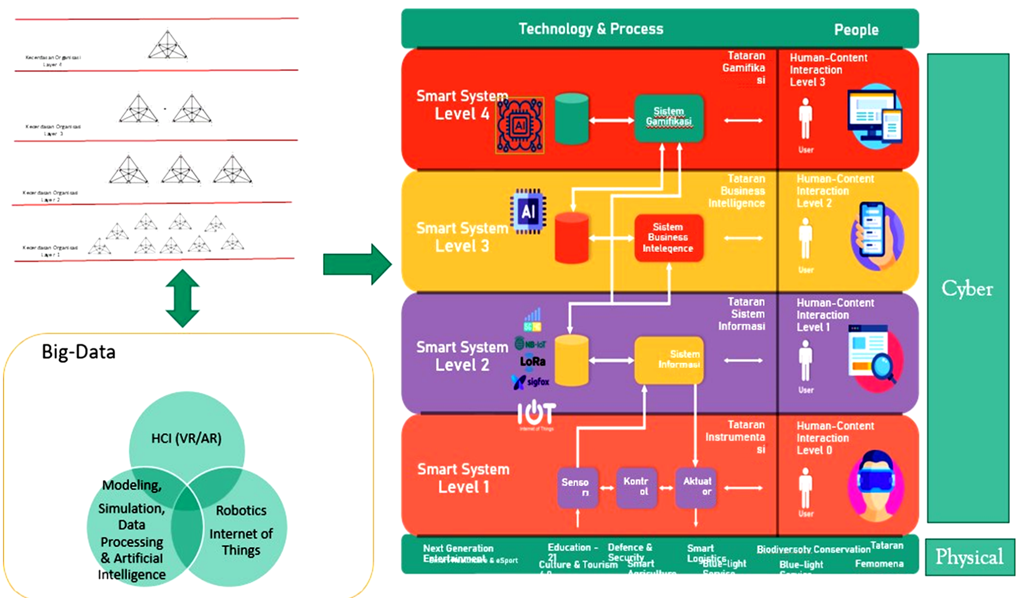


Figure 10: Smart system: Smart organization and 4 modern technologies

Practically, the design and development of smart systems should prioritize the positive impact on human activities. It is essential to analyze and design each unit of analysis in activity theory to be incorporated into a 4-layer smart system. This approach ensures a harmonious role for humans in their interaction with technology, especially artificial intelligence. At Level 1 of smart systems, which pertains to instrumentation, intelligent machines that can serve as tools need to be analyzed for their interactions with the machine itself and with humans who are considered tools in supporting the goals of human and artificial intelligence activities.

### 3.4. Positivism smart system views: The social activity triangle and 4-layer Technology

In the context of positivism ontology, the four technologies (internet of things, big data, HCI augmented reality/virtual reality, and artificial intelligence) can be observed, measured, and explained objectively using rigorous scientific methods. This perspective considers technology as a product of human intelligence, created through accurate observation and measurement. Technology can be continuously developed and improved through research and development efforts. By adopting this view, organizations can utilize technology to enhance operational efficiency and effectiveness across various industries.

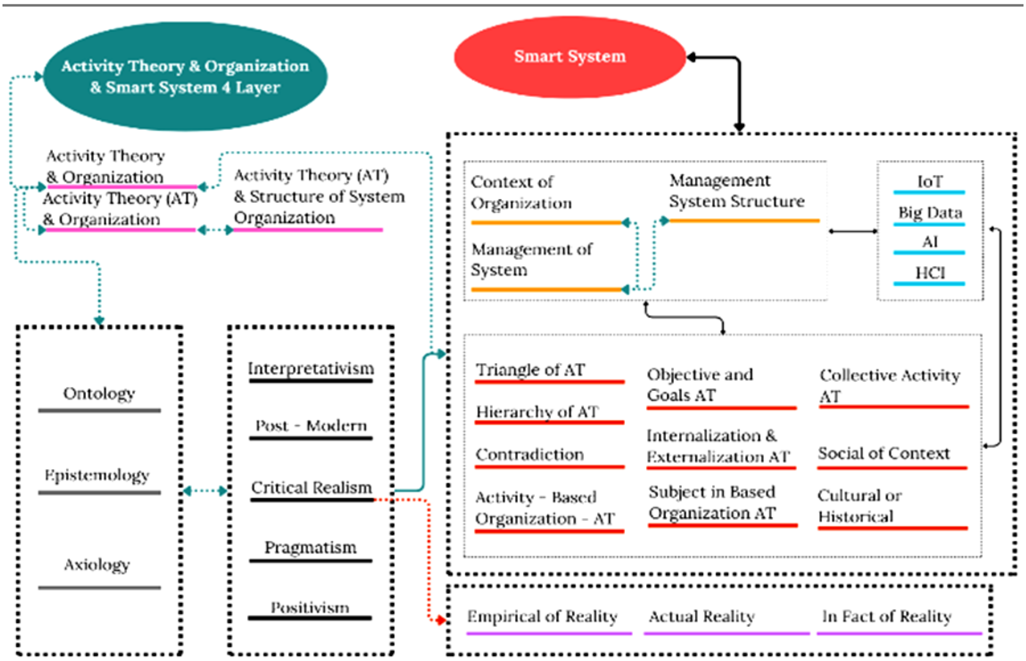


Figure 11: Picture of ontology, epistemology and axiology diagrams of smart system

The integration of the organizational system structure with the concept of activity theory aims to optimize organizational performance and leverage existing potential by considering interactions between subjects, objects, and tools, as well as other factors such as rules, community, and division of tasks. Meanwhile, the implementation of technologies like internet of things, big data, HCI augmented reality/virtual reality, and artificial intelligence allows for effective data collection, analysis, and processing, providing valuable insights for organizations. Internet of things facilitates real-time device connectivity and data collection, big data enables scalable data management, HCI augmented reality/virtual reality develops intuitive and interactive interfaces, and artificial intelligence processes data and provides accurate analysis. The overall integration strives to create a more efficient and effective system in utilizing technology.

If artificial intelligence and humans are considered subjects in activity theory from a positivism ontology perspective, artificial intelligence is viewed as an entity capable of interacting with the environment and humans within the context of activities. artificial intelligence is seen as part of a larger system that includes people, objects, and other tools. Positivism ontology recognizes artificial intelligence as a technology that can enhance the efficiency and effectiveness of human activities within an organization or system. By optimizing the interaction between humans and artificial intelligence, a more productive and efficient system can be created. Positivism ontology acknowledges that while artificial intelligence assists humans in carrying out activities, it also considers human limitations and influences in the development and use of artificial intelligence technology.

### 3.5. Pragmatism smart system view: The social activity triangle and 4-layer modern systems

In pragmatism ontology, ontology is seen as a tool for constructing models that can be applied in different situations to solve real-world problems. The integration of the activity theory triangle and 4-layer modern systems in smart system development reflects a pragmatist view that holds significant value in both academic and practical contexts. The pragmatic view emphasizes a structured and systematic approach to achieve observable and effective results in real-world situations. It recognizes the importance of considering the actual context in smart system development, enabling the analysis of complex human activities within specific social and environmental contexts. By understanding user needs, environmental demands, and the role of technology, smart systems can generate solutions that are better aligned with desired goals.

Effective use of data is also emphasized in the pragmatic view of smart system development. The integration of the activity theory triangle and the 4-layer modern systems enables comprehensive data modeling and analysis through the processing and modeling layers. This empowers smart systems to optimize the utilization of available data, generating valuable insights, deeper understanding, and relevant smart solutions. User interaction and experience are central considerations in the pragmatic view. The integration allows the design of interaction and user layers that account for user needs and preferences. Following the principles of activity theory, smart systems can be developed to support collaboration, encourage optimal user engagement, and deliver a satisfying user experience.

The pragmatic view places importance on a practical and measurable approach to smart system development. The integration of the activity theory triangle and the 4-layer modern systems provides a structured and scalable framework, facilitating systematic evaluation, iteration, and adjustments based on observed experiences and results. This approach enables smart system developers to design solutions that can be effectively implemented in real-world environments.

### 3.6. Critical realism's view of integration of activity theory and 4-layer modern systems

The view of critical realism offers a distinct perspective on the integration of activity theory and 4-layer modern systems in smart system development. Critical realism focuses on understanding the relationship between objective reality and social construction and recognizes the significance of considering both structural and agency aspects in the analysis of smart systems. While activity theory emphasizes human activity as the central focus, critical realism adds attention to the social, political, and economic factors that shape the structure and conditions of smart systems. It raises questions about how social and systemic structures influence human actions and the development of smart systems.

In the integration of activity theory and 4-layer modern systems, critical realism emphasizes a deep understanding of the role of structures and their impact on human activities, data utilization, algorithms, platforms, and applications in smart systems. This approach acknowledges the importance of recognizing and critically examining the limitations and frameworks present in smart systems. By considering both structural and agency aspects, critical realism underscores the need to critically assess the smart system being developed, including the involvement of actors and the potential social interests at play.

The critical realism view brings a broader and critical perspective to the integration of activity theory and 4-layer modern systems in smart system development. It emphasizes understanding and addressing limitations, social structures, and social interests that may influence the development and implementation of smart systems in a more holistic and critical manner. By incorporating critical realism, developers can gain a deeper understanding of the social context and dynamics surrounding smart systems, enabling them to develop more comprehensive and socially conscious solutions.

#### 3.7. Interpretivism views on activity theory and 4-layer modern systems

The interpretivism view provides a distinct perspective on the integration of activity theory and 4-layer modern systems in smart system development. Interpretivism emphasizes understanding and subjective interpretation of human experiences, as well as the significance of considering the social and cultural context that influences the development of smart systems.

In the context of the integration of activity theory and 4-layer modern systems, interpretivism highlights the importance of understanding human activity, the meaning ascribed by individuals, and the surrounding social context. While activity theory focuses on human activity as the primary focus, interpretivism adds attention to individual interpretations and experiences in using smart systems. It recognizes that individual meaning and understanding of smart systems are crucial in their development and usage.

Interpretivism emphasizes that the development of smart systems is not solely about technical factors, but also about understanding how individuals interact with and interpret smart systems within their own contexts. In the integration of Activity theory and 4-layer modern systems, interpretivism focuses on a deep understanding of how individuals and groups analyze, interpret, and give meaning to their activities within Smart Systems. It recognizes variations in interpretation and individual experiences, acknowledging that the use of smart systems can vary depending on the context and culture.

Moreover, interpretivism emphasizes the importance of involving users in the development of smart systems. It underscores the need for a comprehensive understanding of individual needs, preferences, and experiences in using smart systems. By considering the user's perspective, smart systems can be better designed and developed to cater to the specific needs of their users.

#### 3.8. Postmodernism views on activity theory and 4-layer modern systems

The postmodernism view provides a distinct approach to the integration of activity theory and 4-layer modern systems in smart system development. Postmodernism emphasizes diversity, complexity, and multiple interpretations within social, cultural, and political contexts.

In the context of the integration of activity theory and 4-layer modern systems, postmodernism emphasizes that there is no single interpretation or definitive understanding of smart system usage. Postmodernism rejects the notion that there is one dominant narrative that can simplify the complexity of human interactions with smart systems. Instead, it recognizes and embraces the diversity of interpretations and understandings that can emerge from different perspectives, contexts, and experiences.

The postmodernism view highlights that the understanding and interpretation of smart systems can vary among individuals, groups, and cultures. It emphasizes that the interpretation and use of smart systems are influenced by complex social, cultural, and political factors. This approach encourages an understanding that smart systems are social constructions shaped by various powers, forms of knowledge, and ideologies.

Moreover, the postmodernism view emphasizes the importance of recognizing vulnerabilities, uncertainties, and contradictions in the development and use of smart systems. It highlights that smart systems cannot be viewed as objective entities detached from social and cultural contexts. Instead, they are understood as entities that are inherently intertwined with power dynamics and politics, giving rise to ethical and social questions.

The postmodernism view underscores the diversity of interpretations, the complexities of social and cultural contexts, and the role of power and politics in shaping smart systems. It emphasizes that there is no single correct interpretation of smart system usage and acknowledges the existence of contradictions, uncertainties, and ethical considerations associated with this technology.

## 4. Conclusions

The integration of 4-layer modern systems and activity theory in the development of smart systems offers significant potential for enhancing their effectiveness and efficiency. By utilizing the capabilities of each layer in the system, including instrumentation, information systems, business intelligence, and gamification, smart systems can collect data, process information, analyze business operations, and provide satisfying user experiences.

Activity theory provides a valuable framework for analyzing the complex interactions between users, technology, and the environment within the context of smart systems. It allows for a comprehensive understanding of how human actions, technological tools, and contextual factors influence the functioning and outcomes of smart systems. This perspective acknowledges the socio-technical nature of smart systems, considering the roles played by humans, technology, and processes.

From an ontological perspective, smart systems are viewed as intricate socio-technical entities that involve the interplay between human actors, technological components, and operational processes. This holistic view recognizes the complexity and interdependencies within smart systems, enabling a deeper understanding of their dynamics and potential for development.

The insights provided in this article have significant implications for practitioners, researchers, and decision-makers involved in the development and implementation of smart systems. By integrating 4-layer modern systems and activity theory, this new paradigm offers guidance for designing smart systems that are user-oriented, efficient, and effective. It considers important aspects such as ontology (the nature of smart systems), epistemology (how knowledge is acquired and applied), and axiology (the values and ethics associated with smart systems).

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