Paper reading sheet

1. Bibliographic data

1) Title, authors, year, publication.

The research paper described in this reading sheet has the title "Requirements in the 21st Century: Current Practice and Emerging Trends" and was created by Sean Hansen, Nicholas Berente and Kelle Lyytinen, from the Department of Information Systems of Weatherhead School of Management of Case Western Reserve University.

This paper was published in "In Design Requirements Workshop" book, LNBIP (Vol. 14, pp. 44–87) in 2009.

2. Theme of the paper

1) Scientific area, specific topics.

This paper focuses on the study of design requirement processes and the grand challenges it poses in the design of software-intensive systems.

The design requirements processes refer to a range of activities involved in determining what features and functions an artefact must embody and what constraints it must satisfy.

The objectives of this article consist of not only reviewing the main strands of requirements research in the last two decades, in order to identify new and old challenges alike, but also analysing the current state-of-the-art in both its practical and theoretical fields. This is done to identify the gaps between research and practice in this area as well as uncover avenues for future research into the topic.

To achieve these goals, the paper explores: the types of activities and assumptions that characterize contemporary practices of managing design requirements, the differences between requirement practices and perspectives on design requirements reflected in the research literature, the types of tasks typical in current requirements processes along with their newly emerged challenges and which trends are currently driving requirements practice and are expected to continue doing so in the future.

3. Synthesis of the paper

1) Motivation and importance of the research

The subject of this article is motivated by the essential need for the use of design requirements processes in software-intensive design efforts.

The importance of the topic stems from findings that show that the lack of attention to the needs and envisioned functions of a system lead to rising cost in the creation of software, as well as: missed schedules, unhappy users, waste, duplication and an endless cycle of patches and repairs that could have been avoided with problems in the requirements process, often going undetected for a long time and ending up being attributed to bad design and technological limitations.

These efforts, however, face challenges due to various factors including: the complexity of the requirements tasks, the limits of human information processing and the necessary interactions between designers and the intended users. The latter is often cited as the biggest impediment to effective requirement processes with the issues in communication, often rooted in the fact that users tend to not completely understand what they want to achieve, leading to the fundamental misunderstanding of the project requirements. Finally, these processes are also unavoidably intertwined with the politics of resource allocation and legitimacy of decision-making within an organizational environment, which can cause their fair share of impediments.

With the challenges and consequences posed in this section, the paper makes clear why research in the area is necessary, however, researchers have noted that there is a gap between research and practice even though the area of inquiry is ostensibly motivated by real-world concerns of designers. The reason for this is attributed to both practitioners being slow in adopting requirements methods developed by researchers and researchers often turning a blind eye to actual practices and needs of designers.

The rest of the article then aims to address this discontinuity between the research and practical fields of the design requirements processes.

2) Main points of the background information and state-of-the-art

To contextualize the reader in the current state of requirements research, the paper starts by offering a short overview, describing it as a process that has a primary aim of solving the issues described previously. This leads to its content focusing on analytical frameworks, standards for the quality of requirements, elicitation approaches and modelling methodologies rather than advancing the equally important theoretical or empirical understanding of how design requirements are discovered, defined, negotiated and managed and why these processes are so difficult. Furthermore, due to issues with access and threats of internal validity, prescriptive modelling and project methodologies have often not been subjected to rigorous empirical scrutiny.

It is also pointed out that requirements processes are far from monolithic and can be divided into various facets with the article dividing into three different phases: *discovery*, *specifications,* and *validation & verification*. Furthermore, these three activities are employed iteratively, making the requirements more detailed and more in line with the user's needs with each iteration.

However, it is observed that despite their strong interconnectivity, research has often focused on one of these phases at a time and therefore the article is forced to proceed by exploring in more detail each of them to acknowledge assumptions and discuss persistent challenges of each phase.

Discovery is described as the component where a designer or a design team must determine what organizational or customer needs must be addressed by the design artefact and is the primary process by which designers gain knowledge of the relevant application domain. The main specified approaches are as follows:

- The most rudimentary approach is introspection on the part of the designers, which consists of designers reflecting upon or imagining design features that they would find desirable, given their understanding of the application. This approach however, due to not involving a direct discussion with other design stakeholders, could lead to a list of requirements too divorced from the needs of the user if not used in an iterative technique.
- Focus groups and Interviewing are the most widely noted discovery techniques, emphasizing a discussion between representatives of the design team and those closest to the application domain around current experience, areas of discontent with the existing environment and desired changes that design artefacts might engender. These methods however are often subjected to bias, related to the designer's line of questioning.
- Direct observation eliminates the need for explicit discussion but requires detailed understanding by the designer of the way that activities unfold in practice.
- Protocol analysis and use of ethnography are data-intensive discovery techniques which have been proposed to enhance the identification and assimilation of tacit information during requirements processes. Unfortunately, the former is prone to overlook nuances of activities and the latter can be costly and consume a significant number of resources.
- Prototyping consists of the development of an early, rudimentary version of a system with its essential features and is particularly effective in establishing a common basis for understanding and communicating ideas between designers and stakeholders. However, this method may lead to unorganized code, and resistance to change in features implemented in the prototype and can be problematic in the development of large systems.

These techniques might be used in conjunction to achieve better results with no single technique being appropriate for all design contexts. The discovery process chosen can have a great impact on the quality and quantity of the requirements, so the use of a combination of techniques enables designers to adopt multiple perspectives on the application domain with the careful selection of appropriate techniques for a given situation being described as the hallmark of a truly experienced analyst.

Finally, it is pointed out that the degree to which these techniques have been adopted in the real world and under what conditions is unclear since, despite the existence of some evidence that formal discovery techniques have been effectively applied by technology consultants and expert users, their degree of acceptance in a broader industrial context remains an open question.

Moving on to **specifications**, this phase is referred to as the process in which the stakeholders' needs are rendered in some concrete format and representational scheme. A requirements' specifications should support interpretation and understanding among all design stakeholders around what the artefact is supposed to accomplish while at the same time laying a sufficient technical foundation for the subsequent development effort,

representing the point of transition where the stated needs of stakeholders will be extended with their functional and technical implications.

It is also mentioned that in the past the view on requirements was that they should only be concerned with what is to be achieved and not how to achieve it, however due to rising system complexity and interdependencies between systems there is now a need for incorporating design considerations and key constraints on the design space during specification.

The specifications phase should produce a requirements specification document where designers usually combine natural language with formal or semi-formal models of the application, problem, or design space.

Natural language is utilized due to it being the language commonly used by stakeholders to express their needs and therefore design requirements at the highest level are rendered through natural language descriptions, furthermore, it also has the advantage of acting as a common basis for communication between designers and stakeholders and having the ability to provide a great deal of information about contexts of use. Finally, its use is inevitable since it's impossible to achieve fully formalized articulations. Most research has, however, emphasized its many limitations and proposed ways of overcoming them. These limitations include the ambiguity of natural language, which could lead to misunderstandings between designers and stakeholders and its incompleteness and inaccuracy stemming from the informal nature of the language which inhibits explicit analysis. Additionally, natural language descriptions hide inconsistencies because they provide little basis for direct comparison across statements.

To attempt to compensate for the shortcomings of natural language described above, researchers have pursued natural language processing capabilities to automate the generation of formal models, however, the bulk of the research developed focuses on ways to augment natural language representations with formal or semi-formal models of requirements.

Modelling consists of the creation of abstract representations of the real world using limited and established symbol systems with the portion of the real world to be modelled consisting of the application domain and its relationship with the proposed design. The resulting models reflect abstractions, assumptions and known constraints within the design domain. The use of models has several key benefits associated with formal specifications such as establishing a baseline of understanding, facilitating communication between distinct shareholder groups, and enabling formal analysis to identify unstated requirements, predict behaviour, determine inconsistencies between requirements and check for accuracy. Lastly, models simplify the application domain by focusing on essential features in line with the principles of abstraction (the process of inducing essential elements or processes from specific statements about the application or problem) and decomposition (the process by which systems are partitioned into smaller components).

Despite all the research described above, research into models still has major failings such as an emphasis on the perspective of the designer without any regard for the preferences of the stakeholders, which limits their usefulness.

Models can be developed at multiple levels of detail with the main contemporary design efforts identified being the following:

- **Enterprise modelling** refers to the development of models to reflect the design's broader organizational or market context. Its objective is to help achieve a better understanding of the application domain and the independencies it embodies with a focus on interactions between a system and its environment. (Examples: rich pictures, use cases, business process modelling, enterprise-level architectural modelling)
- **Functional requirement modelling** focuses on representing requirements about the design artefact itself abstracting it from the environment with most of these modelling approaches being specific to the context of information system design. These techniques can be characterized based on the ontological perspectives they apply to the application domain with these ontological categories also going by the name of meta-model characterizations. Of these categories the paper speaks of the following:
    - State Models – Model of a system as a set of distinct states and the modes of transition between states. Appropriate for event-driven systems.
    - Structural Models – Model of a system based on the structural features of the application or domain.
    - Activity Models – Model of a system as a collection of activities. Appropriate when data is affected by a sequence of transformation at a constant rate.
    - Object-Oriented Models – Model that incorporates many concepts and fundamental techniques in other methods.
    - Agent-based Models - Model of complex systems as a collection of autonomous decision-making agents. Appropriate for the simulation of emergent phenomena.
    - Goal-Oriented Models – Model of the underlying objectives that motivate a design effort.
- **Non-functional requirement modelling** focuses on the development of models to identify the constraints or restrictions on the design domain while also incorporating the quality expectations for a system.

Finally, while most modelling methods were created as individual techniques for representing an application or domain, recent trends have been towards integrating across different modelling perspectives. A big perpetrator of this change was the introduction of the Unified Modelling Language (UML) which consists of an outgrowth of the object-oriented specification tradition while incorporating a broad suite of model techniques such as class diagrams, state-chart diagrams, activity diagrams and use case diagrams.

Other than the move towards integration, modelling research has been marked by two opposite movements, with the conflict between these two trends being one of the pressing questions in research around requirements specification:

- Increased standardization in the specification of notation systems and processes with the idea that the diversity of modelling techniques poses an impediment to their adoption.

- Increased customization of modelling based on the types of systems or contexts involved called Situational Method Engineering (SME)

Validation & Verification is the phase in which we check whether requirements processes have been conducted effectively and the degree to which the specifications will support productive design efforts.

Validation is described as the effort to ensure that requirements accurately reflect the intentions of the stakeholders and despite being in the last phase described it usually begins almost at the same time as the discovery phase and continues through the specification phase (prototyping can be used as a key validation technique).

One of the potential issues in requirements validation is the existence of disagreements with the stakeholders but effective management and resolution of such conflicts are essential if a design effort is to advance. Due to that, the following techniques have been proposed to help designers with conflict resolution:

- Requirements prioritization – Process of determining the relative value of the individual sets of requirements and using those values to mediate between conflicts that may arise.
- Requirements negotiation – Process of identification and resolution of conflict through exploration of the range of possibilities available.
- Requirements resolution – Process of building upon the *viewpoints* thread within requirements research which refers to the emphasis on obtaining design requirements from individuals and groups with different perspectives on the design.

Verification is described as the degree to which requirements conform to the accepted standard of requirements quality including consistency (requirements should not conflict with the overall design effort or with each other), feasibility (the degree to which a given requirement can be satisfactorily addressed within the design environment or organization, including how it can be maintained), traceability (the degree to which individual requirements can be tied to both higher order objectives and detailed elements) and the absence of ambiguity.

Several techniques have been proposed to support verification, with some key techniques including formal inspections, structured walkthroughs, and automated consistency checking.
In conclusion, requirement scholars have consistently strived to improve the lives and resources of designers, however, the degree with which these efforts have resonated with practising designers remains to be seen and while some incentivize the adoption of techniques from research, others bemoan the growing gap between researchers and the practising design community.

To explore the current state of requirements practices in a variety of organizational and industrial contexts the authors of the paper conducted a series of semi-structured interviews with IT and design leaders from the United States of America and Europe with the data collection structured around an interview protocol jointly developed by the researchers and was designed to elicit responses to several distinct aspects of the professionals' design experience. The core protocol was kept constant throughout the data collection process except

for the addition of some questions to the protocol based on insights from the initial interviews in line with the grounded theory concept of constant comparison.

To foster external validity and address threats to internal validity, the research team sought participation from individuals and firms engaged in a wide variety of design environments, from business and design contexts from areas the researchers expected to observe the significant market and technological change occurring, and from leading-edge mainstream organizations. In the end, a total of 30 interviews were conducted with 39 individuals participating of which the results were kept anonymous.

The contexts of studied systems and their requirements included the following:

- Large, complex organizational information systems.
- Embedded systems.
- eBusiness Applications.
- Middleware systems.

The approach used is likely to have a bias towards large, complex, systems to focus on practices associated with the most challenging development contexts with the system development efforts reflected in the study involved from tens to hundreds of man years and costs between several million to hundreds of millions of dollars.

All interviews were transcribed to support formal analysis of the data and all transcripts were then coded using "Atlas.ti".

3) Main findings and results and their novelty

The paper describes several key observations regarding the current practice of requirements management from the results of the field study.

With regards to common practices in the field, it was observed that overall requirement practices have evolved significantly over the past decade, often in line with the technique proposals offered in academic literature including the following practices:

- Fostering the involvement of a variety of stakeholders.
- The use of supporting CASE tools.
- Development environments based on tools such as IBM's Rational Suite.
- Risk mitigation is common, with many participants noting that project risk mitigation is a central area of development focus and some informants indicated that portfolio risks are consistently measured and actively managed.
- Requirements activities commonly include focus group discussions, cross-disciplinary project teams and requirements sign-offs from an array of stakeholder groups.
- The use of sophisticated process modelling activity, including the widespread application of use cases even in situations where other elements of UML were not adopted.

Meanwhile, while principles such as traceability and structure process improvement were not very prevalent in current design practices, they had significant consideration in the future efforts of the interviewees. Similarly, trends like web services/service-oriented

architecture (SOA), as well as outsourcing of development, was reported as influencing current requirements practice.

On the other hand, however, many prevalent concepts and distinctions in literature were not employed by designers:

- Few interviewers made a distinction between functional and non-functional requirements choosing to document them in the same manner.
- While characterizing requirements processes several interviewers expressed the belief that requirements processes are indistinguishable from the design and felt that requirements questions are properly interspersed in the design process.
- Designers did not mark distinctions in requirements activities such as elicitation, specification, …
- Within an organization, professionals are seldom expected to adhere to explicit methodologies leading to a hazardous application of standardized and more formal methodologies. In most projects, a combination of techniques is used at the discretion of project managers with constraints such as budget, personal needs and the number of systems impacted being key considerations in determining how rigid processes should be.
- Management of conflict within designs was found largely unproblematic with the simple prioritization of requirements by a key sponsor or stakeholder. Usually, this prioritization is tied directly to funding and transfers the valuation of requirements from the design team to the stakeholders.

Finally, the study concluded that the most significant impediments to a project lie in the interpersonal aspects of a design effort, namely due to the stakeholders not knowing what they want, knowing what they want but not being able to express it or limitations in communication skills from the design team. On the other hand, respondents didn't feel like the absence of appropriate modelling approaches and tools set up a significant challenge to their requirement processes.

The application of formal methods throughout the design was noted as a measure for future development and improvement.

While the interviewees did not distinguish between requirement activities the interview protocol allows them to get an insight into regarding their approaches to these activities.

Regarding **Discovery**, it was found that a relatively narrow range of techniques was employed with most organizations relying on focus groups and other group-based discussions and even one-on-one interviews with stakeholders. More intensive measures were also noted by a small number of respondents, but they were far less common. Validation and discovery also often occurred simultaneously (frequently in the form of prototyping or other forms such as "blueprinting").

Another finding is the degree to which requirement articulation has been established as the responsibility of the relevant line of business or other stakeholder groups. Stakeholders are expected to engage the design team with a detailed statement of needs beyond the business requirements. As a result, requirement discovery on the part of the design team

consists mostly of clarifying and assessing gaps instead of a comprehensive frontal elicitation effort.

On the topic of **Specification & Modelling**, an important observation is that design professionals did not speak of specific modelling techniques employed but rather modelling tools used. Platforms such as "IBM's Rational suite" and "Telelogic DOORS" were more salient than the specific types of models used. One exception to this however is the Use Cases model which was mentioned by almost all interviewees as a central aspect of their specification activity.

Modelling was mostly described as an informal process with extensive use of natural language which is consistent with the widespread use of Use Cases. Additionally, several participants talked about the use of processes or workflow models as well as data models/ E-R diagrams. The use of UML was also implied through the application of Rational software, but few interviewees specifically mentioned that a part of their requirements process was based on UML.

Finally, when it comes to **Verification & Validation** the interviewees didn't note the adoption of formal approaches to verifications or requirement checking with the majority verifying the correctness and assessing the consistency of requirements through informal review and discussion among the design team.

When it comes to validation a greater degree of formality was observed with efforts cantered around explicit sign-off by project sponsors and other stakeholders who are expected to review the requirements documentation and acknowledge their acceptance so that the design effort can continue. A challenge from this approach however is that due to various reasons, stakeholders frequently fail to properly review the documentation leading to design efforts proceeding despite the presence of requirements errors which can be exacerbated under conditions of multiple sign-offs due to ambiguity and diffusion of responsibility.

Furthermore, interviews noted the frequent use of prototyping and system walkthroughs as validation mechanisms and while none of the organizations represented was extensively involved in agile development several talked about iteration and prototype development. Lastly, a few firms indicated the use of novel validation tactics such as validation of use case "personas", validation of time estimates and stakeholder voting.

Other than current practices, several recurring themes and issues were identified from the data collected which tap into emerging trends or patterns and are not captured adequately by the requirement literature.

Firstly, a focus has emerged towards **Business Processes** with requirements for technological artefacts being driven by business processes, something not apparent in most related literature. Accordingly, boundaries between business processes and IT seem to be becoming increasingly blurred with the logic behind business investments in IT emphasizing having organizational priorities and processes to drive IT rather than letting IT capabilities determine the priority of activities.

This trend towards the design of business processes also leads away from system boundaries based on arbitrary functional or divisional criteria and towards **System**

Transparency which demands a single user experience across applications with technologies being expected to converge to generate a perception of a single service platform. This principle differs significantly from traditional requirements literature's emphasis on the notion of usability associated with a specific application.

To accomplish "user-centricity" as described above it is necessary to link different applications leading to a focus on the **Integration** of existing applications and system components rather than designing individual artefacts. This implies a critical change in the role of internal IT groups which act more as integrators than developers with most of their work consisting of assessing and maintaining interdependencies between systems instead of traditional functional requirements and subsequent design.

Another pattern that emerged during the study was the increased **Distribution of Requirements** processes across function, organizational and geographic boundaries with no single organization or functional unit being responsible for the development of the bulk of design requirements. This means that vendors, consultants, enterprise architects, development teams, business stakeholders and individual users all play a significant role in defining and implementing requirements.

Globalization and the adoption of outsourcing have also played a critical role in this trend leading to the geographic spread of requirement discovery and development efforts which in turn brings with it business contexts and features that are tied to distinct locations and business environments. Finally, the prevalence of COTS applications and the growth of industry-wide standards have also contributed to the significant distribution of requirements discovery and validation efforts among multiple independent organizations with this phenomenon being amplified by the complexity of packaged systems and the increasingly limited knowledge organizations have in formulating solutions.

Distribution requirements also enhance parallelism in the requirements processes a topic not very discussed in literature due to the traditional focus on singular individuals or teams managing requirements processes.

Another emerging trend is the use of **Layers of Requirements** which are generally needed for contemporary design efforts where the layers may be associated with different levels of abstraction, design focus, user orientation or timing. This layering phenomenon includes the traditional transition through business functional and technical requirements and organizing requirements based on the level of analysis.

Furthermore, the volatility or timing of requirements is also an important basis for layering with requirements that are expected to persist over a long period, needing different approaches from requirements that may change rapidly and in less predictable ways. This aspect is relevant when talking about the design of embedded systems and product lines since the design volatility for the embedded artefact in the product differs significantly from that of underlying software systems.

For system design efforts a clear preference towards **commercial-off-the-shelf (COTS) or packaged software** rather than the development of separate software was observed representing a major point of departure from the research tradition where requirement

practices take place in the context of green field development where the final product is new software. Requirements for packaged software are significantly different with greater involvement from software vendors and consultants who often take the lead in requirement processes. This in turn forces the requirement process to begin with more of a gap analysis between the processes supported by the packages and the desired work practices instead of the traditional focus on the "what" of a design effort.

Despite the prevalence of COTS, many interviewees were quick to reflect on the drawbacks of their use with the firm becoming dependent on large enterprise vendors. However, they appeared to believe that the benefits such as lower cost and better predictable quality outweighed the drawbacks.

Another trend detected in the interviews was a growing recognition of the importance of information **architectures** in establishing the context for requirement processes with adherence to established information architectures becoming a critical constraint and concern for all design efforts. In large part, this is due to the need to address integration complexity and the need to maintain consistency in applications and organization-wide designs.

Due to the study including both IT units and product development organizations both enterprise architecture and product architecture were mentioned.

Many indicated that enterprise architectures, especially those associated with the internal IT infrastructure were becoming critical as organizations look to integrate extensive portfolios of applications that have resulted from precious stove-piped legacy development as well as the benefits It brings during organization mergers and acquisitions. All of this leads to architecture driving the requirements of specific artefacts rather than the opposite with the possibility of acting as a significant constraint to requirement processes or simply changing their structure.

On the same note, organizations developing products focused more on developing formal product architectures to support the managed evolution of their offerings something extremely important due to the rapid rate at which technologies change.

In the interviews, an increased appreciation for **Fluidity of Design** or the continued evolution of design artefacts was also shown. Although artefacts have always evolved after use, traditionally there was always a point at which a project was viewed as complete. However, these design assumptions have begun to die down as designers recognize that projects are often a single step of an iterative process. One strategy employed to deal with this evolution was to limit the scope of projects intentionally with planned and managed releases later to set expectations correctly.

Considering that users always find ways to use artefacts in odd ways, many firms are increasingly aware of this fact and are not attempting to define all requirements at a time but instead, they attempt to find additional mechanisms to allow the user to personalize artefacts by building open interfaces. Solutions to this unknown user-led evolution involved increased reliance on interface standards and standardized platforms embedded into products with accommodations to include multiple add-ons having become the main objective of requirements.

The final theme mentioned by interviewees in the paper is the perception of increased complexity associated with varying technologies, requirement efforts, and design processes. It has long been observed that complexity is an essential property of system development however the level at which complexity emerges has shifted from the internal complexity of the software to the **integrative complexity of interdependent systems**. This means that despite the deployment of modular designs and architectures, complexity has increased due to the large number of interdependent systems, the increased number of new systems that must be integrated with legacy and the sheer magnitude of integration-oriented requirements given all the themes.

4) Main conclusions and/or discussion points

The discussion section of the paper starts by pointing out that the conducted study opens a series of avenues for researchers interested in the requirements design phenomena, pointing out that they should take note of how assumptions that currently underline the current research tradition inhibit them from understanding how requirements' work is accomplished in practice.

In terms of **current practices versus the research tradition**, it was observed that a great deal of progress was made in recent years. System development organizations employ a lot of principles that researchers have been advocating for, such as formal validation and sign-off, enterprise and functional modelling, user involvement, explicit risk management and the use of CASE tools, however, there also appear to exist inconsistencies between the way practitioners and researchers view requirement processes.

One such example is the way that in practice distinctions are rarely made between facets in requirement processes with them often happening simultaneously and being largely mediated through natural language and various artefacts. This is in part due to the iterative nature of the design process, where discovery and verification never really cease, even after the delivery of a system.

Another important instance of this disparity is the value given to formal modelling techniques by the research community as a method of communicating more effectively with users, when this is not the case in practice. Models are instead usually derived from natural language representations and created after requirements have been generated and approved with communication with users being instead achieved through semi-structured formal language. With this in mind while the widespread adoption of use cases shows that more precision in communication between users and designers is desired a more appropriate pursuit for researchers might be the augmentation of formal models within organized and structured natural language representations.

Finally, it's necessary to understand that a lot of academic literature is focused on systems developed from scratch to support a specific set of operational activities where requirements for the system were in the heads of users and it was up to developers to elicit these requirements to guide the system design. However, as has been extensively talked about, this assumption is incorrect with multiple stakeholders being affected by the system and with hard-

to-access requirements with a tendency to change over time. While methods such as prototyping and ethnographic methods have been adopted to help designers move forward beyond the limitations of traditional methods these approaches are still methods to improve the extraction of requirements for downstream increased formalization.

On the topic of **newly emerging forces in requirements practices,** several different trends that do not fit into the traditional outlook were found:

- Systems are no longer created for a specific set of activities, with an organization's functional silos.
- Systems are intended to support cross-organizational and inter-organizational business processes or to offer multiple functions over a product's life cycle.
- Multipurpose, expandable devices for a wide array of applications are plentiful.
- Systems increasingly connect and become integrated.
- System boundaries and associated connections are made invisible to users.
- Greenfield efforts are nearly extinct.
- Stakeholders are no longer a fixed or easily identifiable set of individuals.
- Commercial-off-the-shelf (COTS) applications and modular architectures dominate the design landscapes as firms look to buy rather than build due to lower cost and expectation of higher quality.
- Development never ends.
- When one level of complexity becomes black-boxed, additional layers of complexity emerge.
- The requirements process is no longer a dialogue where designers extract requirements from users, instead, they must reconcile negotiating with an ever-expanding set of stakeholders, addressing continual technological changes, and mitigating the complexity associated with these threads.
- The way stakeholders encounter and interact with the software-intensive artefacts that populate their home environment is changing as they start to expect boundaries between artefact systems to fade into the background minimizing the cognitive effort to transition between tools.

This focus towards integration and evolution instead of documentation shows the increasingly creative roles that designers must play in co-producing artefacts instead of just charting out needs from the users *a priori*. This in turn calls for an expansion of the realm of requirements research to address broader organizational aspects of design and the requirements' process.

In this regard, the study calls attention to a wide array of **new avenues for requirements research** and each key finding illustrates an issue that warrants additional exploration, which could help close the research-practice gap within the requirements' arena. The question then is how we can draw upon the research tradition while remaining open to the new phenomena at hand.

The research team of the paper believe that the framework provided by the aforementioned research can be useful in directing the attention of researchers and while the

distinction between facets of the requirements' processes has been blurred, the fundamental concerns upon which they were built remain:

- What does the design need to have? (Discovery)
- How can we render an unspoken vision in an explicit form to which multiple individuals can gravitate? (Specification)
- How can we, as designers, know when we are on the right track and persuade others to think the same? (Validation & Verification)

These high-level conceptual challenges offer a perspective that can be applied to new emerging phenomena among practising design teams.

4. Questions and reflection

1) Questions raised by the reading of the paper

This paper raised questions about what practices are currently employed in requirements' processes and how those real-world practices compare to the ones proposed in research literature in the area. Furthermore, it also asked the important question of what paths research should take and what assumptions researchers should drop, so that this gap could be bridged.

2) My opinion about the paper

In my opinion, the paper raised important questions when it comes to innovation in the area, since research can never be divorced from the real-life practice of Requirements Engineering otherwise it ends up just losing its focus and not helping users or designers in the activity of requirements design. The study conducted also seemed to constitute a good effort in attempting to find the differences in practices utilized by designers in real-life design situations and what researchers have chosen to focus on as their main topics of research.

Lastly, the avenues presented as possible ways of trying to bridge the research-practice gap in requirements processes were not described in very large detail. The paper focuses mostly on the differences between research and practice in order to call researchers' attention towards topics they might be neglecting or approaching incorrectly. This may be since it was created as "food for thought" for a series of two workshops over two years, which aimed to address these issues.

3) What to retain for my future research/professional practice

This paper describes very well the reason why research should never be separated from practice and how what might theoretically work fails to be adopted into the industry for a lot of different reasons, which I believe is something to keep in mind in the future. Furthermore, I believe that another thing is the fact that requirements design processes involve many people from designers to stakeholders. These individuals have vastly different backgrounds and what might be more convenient for one group of people might inhibit another group's understanding (for example the use of formal language in the discovery phase of the

requirements' processes) and the level of understanding of all groups should be considered in research efforts.

Finally, it's important to keep in mind that the area of requirements processes is a constantly growing and evolving area, and it is necessary to keep our eyes open towards the current situation of the industry and its practices to make sure our research is heading in the right direction.

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