A systematic review of evolution of Requirements Engineering(RE) for Information Systems

MASTER'S THESIS PRESENTATION

BY

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Agenda

- Thesis Framework
- Problem Statement
- Significance of the Problem
- Definition of Requirements Engineering (RE)
- Dimensions of Requirements Engineering (RE)
- Why is Requirements Engineering (RE) Difficult
- Research Questions
- Areas of Research
- Areas of Research Defined
- Evolution of Requirements Engineering (RE)
- Findings and Analysis
- Conclusion

Thesis Framework

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Chapter 1

- Introduction of the Problem
- Significance of the Problem
- Research Question

Chapter 2

Literature Review of developments in RE, from historical perspective, against defined criteria

Chapter 3

- Findings – Analysis/Synthesis of developments
- Answer to Research Question

Chapter 4

- Conclusion and future direction of RE

Problem Statement

Requirements Engineering (RE) is one of the most important phases in information systems development. Despite significant research on the subject and it's success over the last few decades, Requirements Engineering (RE) continues to remain a primary source for Information System project failures and plague professionals as they struggle to capture correct and accurate requirements of a project.

The goal of this research is to systematically study the evolution of Requirements Engineering (RE) and explore the research that has been conducted over last few decades, to make an endeavor to understand, why Requirements Engineering (RE) still continues to be the most complex and challenging task in Information Systems development, and prevails to contribute towards failure of projects.

Importance of RE

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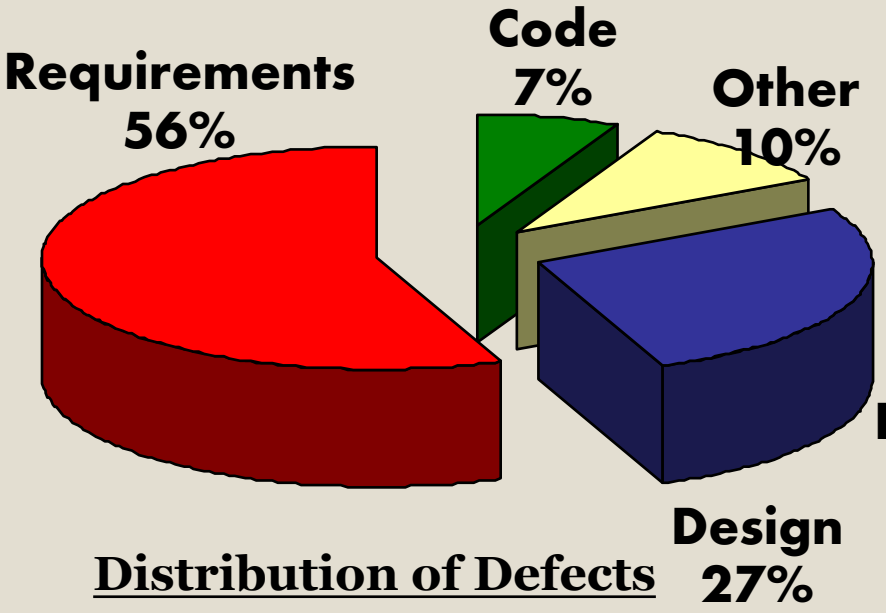
CHAOS			
1994	1996	1999	2000
User involvement	User involvement	User involvement	Executive management support
Executive management support	Executive management support	Executive management support	User involvement
Clear statement of requirements	Clear statement of requirements	Clear statement of requirements	Experienced project manager
Proper planning	Firm basic requirements	Experienced project manager	Clear business objectives
Realistic expectations	Competent staff	Small project milestones	Minimized scope
Small project milestones	Small project milestones	Firm basic requirements	Standard software infrastructure
Competent staff	Experienced project manager	Competent staff	Firm basic requirements
Ownership	Proper planning	Proper planning	Formal methodology
Clear vision and objectives	Ownership	Ownership	Reliable estimates
Hard-working, focused staff	Other	Other	Other

Involvement/ Ownership | Requirements | Management Support | Planning | Staff

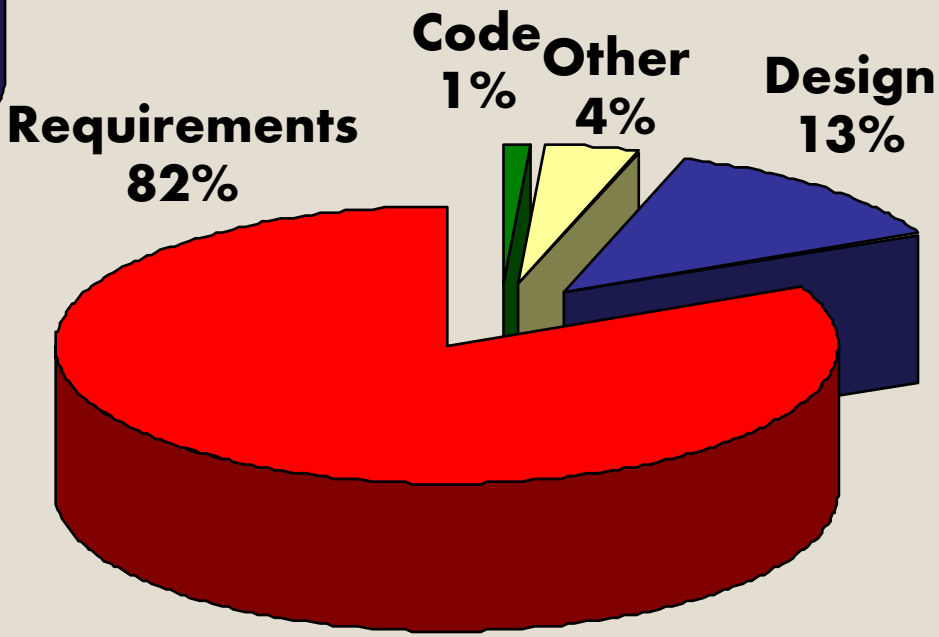
Source: Standish Group Inc., 2000

Importance of RE



Distribution of Defects

Distribution of Effort to Fix Defects



Source: Martin & Leffinwell

Significance and Impact of the problem

Software projects often fail, which could lead to huge amount of losses in terms of financial resources, lives or time, amongst others.

- One notable casual factor in abandonments (cancellation of a project) was the lack of due diligence at the requirements phase (McManus, 2007)
- 60% – 80% of project failures can be attributed directly to poor requirements gathering, analysis, and management (Meta Group)
- Companies with poor requirements and business analysis capability have three project failures for every one project success (IAG Consulting- Benchmark Report, 2008)

Significance and Impact of the problem

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Major Failures in IS systems in various organization.

Year	Org' tion	Project	Outcome	Cause
1990	London Ambulance Service	Computerize Ambulance Dispatch System	A £7.5 million project failed, leading to loss of lives and financial resources.	Breakdown in communication between and management and stakeholders and inadequate testing.
2000	FBI	Automate its case management and forms processing	A $500 million project scrapped in 2003.	Poorly defined design requirements, an overly ambitious schedule and the lack of an overall plan for deployment.
2010	UK National Offender	MIS project, to create single database of prisons in UK. (C-NOMIS)	A £690 million (projected cost) consumed and behind schedule.	Underestimated the need to invest in business change alongside the IT system and underestimated the technical complexity of the project.

Source: ComputerWorld

Benefits/Value of RE

- Requirements Engineering (RE) shape the Enterprise Strategy: Whether a business wishes to exploit advances in technology to achieve new strategic objectives or to organize work in innovative ways, the process of Requirements Engineering could and should present opportunities for modelling and evaluating the potential impact that technology can bring about to the enterprise. (Loucopoulos and Garfield, 2007).

- Form a Project Management perspective, some assessment of a project's feasibility and associated risks needs to be undertaken, and RE plays a crucial role in making such an assessment. It is often possible to estimate project costs, schedules and technical feasibility from precise specifications of requirements. (Nuseibeh and Easterbrook, 2000)

- Better quality of product, better information system design, lower development time, less rework and defects, delivery within the budget and satisfaction of customers.

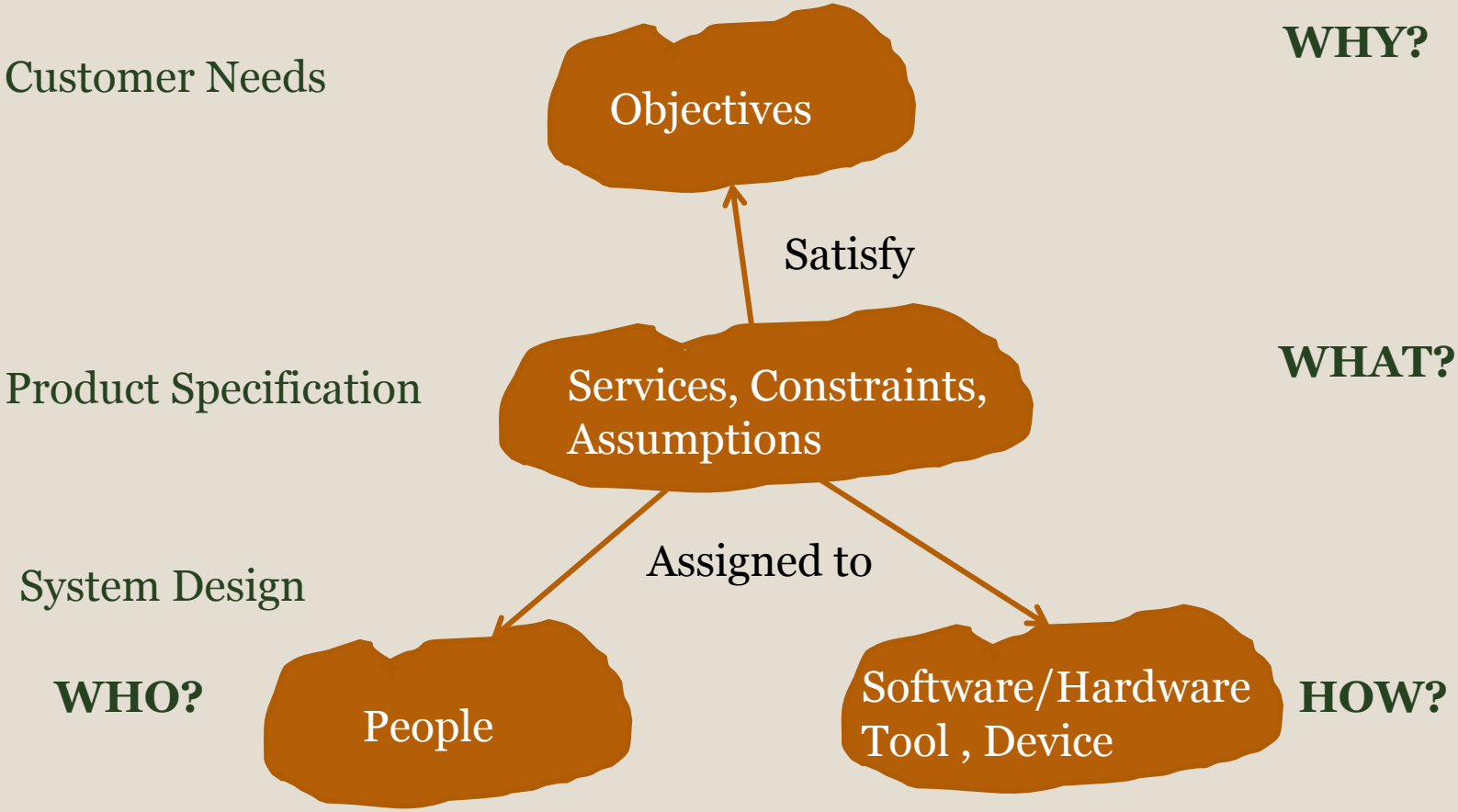
Research Question

- **Question 1**: How have Requirements Engineering (RE) discipline evolved since it started being recognized as a separate discipline in the late 1970s?
- **Question 2**: Why requirements gathering and analysis are still a pain point in Information Systems development projects?
- **Question 3:** Why Information Systems projects continue to be abandoned or are declared failure, attributed to poor requirements engineering, even after so many years?

Definition of Requirements Engineering

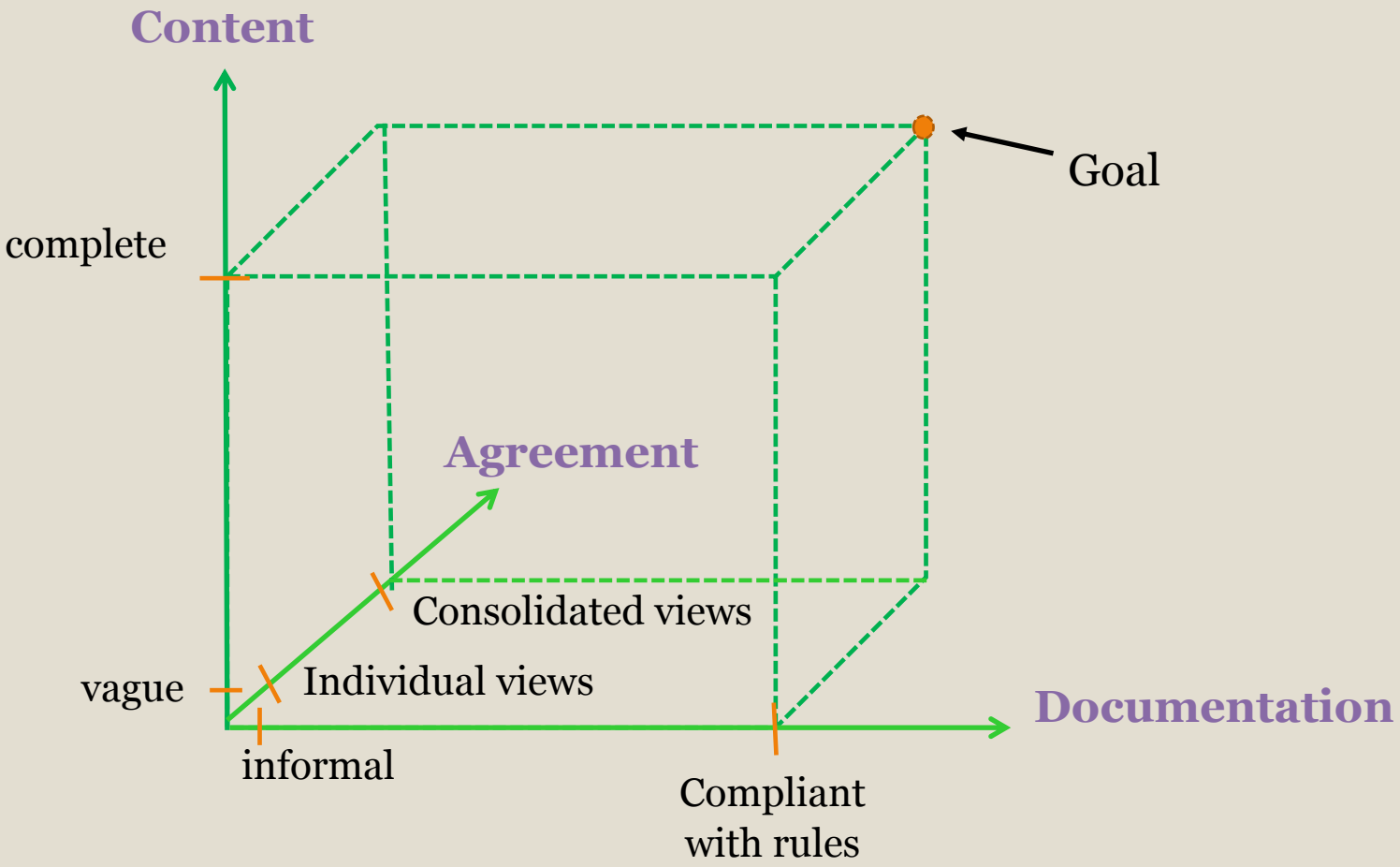
- Requirements engineering is a careful assessment of the needs that a system is to fulfill. It must say why a system is needed, based on current or foreseen conditions, which may be internal operations or an external market. It must say what system features will serve and satisfy this context. And it must say how the system is to be constructed. (Ross,1977)
- Requirements engineering covers all of the activities involved in discovering, documenting, and maintaining a set of requirements for a system. The term engineering implies that systematic and repeatable techniques should be used to ensure that system requirements are complete, consistent, relevant, etc. (Somerville & Sawyer, 1997)

The four dimensions of RE



Source: Ross, 1997, Lamsweerde, 2000 , Muller, 2013

The Three Dimension of Requirements Engineering (Pohl, 1994)



Areas of Research

Sub –Areas as defined by SWEBOK 3.0 , BABOK 2.0

- **Stakeholder Identification and analysis**
- **Stakeholder Involvement and Participation**
- **Requirements Elicitation Techniques**
- **Elicitation of Non-Functional Requirements and system constraint**
- **Consideration of social, organizational, and political issue**
- **Requirements prioritization**
- **Conceptual Modeling and understanding functional requirements**
- **Architecture Design**
- **Documentation of requirements specification**
- **Requirements Verification and Validation**
- **Requirements Process model**
- **Requirements Management**

Areas of Research Defined

Sub-Area	Defined
Stakeholder Identification and analysis	Stakeholder identification should be in all relevant level, such as organization level, system level, and project level (sharp, 1999)
Stakeholder Involvement and Participation	Ensure that all users or users' representatives relevant to the project can participate in the requirements elicitation Process (Eason, 1989)
Requirements Elicitation Techniques	Requirements Elicitation is a process by which tacit information about "what to build" is obtained from the user and his environment. (Holbrook, 1990)
Elicitation of Non-Functional Requirements and system constraint	Non-functional requirements can be considered attributes of the project in general. They include some of the "ilities" such as manufacturability, reliability, supportability, maintainability, affordability, etc. (Mylopoulos, 1992)
Requirements prioritization	RP is the part of Requirements Engineering (RE) that involves mapping the requirements on a scale of importance for the stakeholders (Firesmith, 2004).
Conceptual Modeling and understanding functional requirements	It includes modelling external behavior of the system. Interface and architecture modelling cam be included in this category where it is appropriate. Various techniques can be used during the this process, such as prototyping, scenario, goal-oriented, state-machines, structured modelling, etc. (Davis, 1993 & Lamsweerde, 2000)

Areas of Research Defined (Contd.)

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Sub-Area	Defined
Documentation of requirements specification	Certain documentation language must be used for documentation of functional requirements, quantitative representation is encouraged where it is appropriate. (Sommerville, 1998)
Architecture Design	We define requirements as problem description and software architecture as the structure of a software system that solves that problem, with components and connectors as the main elements. (Boer, 2009)
Requirements Verification and Validation	Verification checklist is different with that of requirements analysis checklist, it defines various aspects that are related to the quality of requirements and specification format to ensure that the final requirements and documentation format meets the standards of the organization or Stakeholders. (Firesmith, 2001)
Requirements Process modeling	The ability to identify problems and suggestions for improvements in the RE process opens up significant potential for increasing the success of software projects. (martin, 2002)
Requirements Management	Document the relationship among the requirements. Establish the trace link and document the link. (Ramesh, 1995) . Includes identifying the changed requirements and document the changes, its sources and rationale. (Kotonya, 1996)
Social, org & political issue	Social, organizational, and political issue are often the major source for elicitation of requirements. (Goguen, 1993)

Challenges of RE

Requirements are inherently difficult -

- Evolving nature of requirements and managing inconsistency in requirements specifications as they evolve is a major challenge. (Nuseibeh & Easterbrook, 2000)
- Requirements engineering is difficult. It is not just a simple matter of writing down what the customer wants. A fundamental problem in our business is that requirements are inherently dynamic-they will change over time as our understanding of the problem we are trying to solve changes(Young, 2001)
- The requirements problem space is less constrained than the software solution space – in fact, it is the requirements definition that helps to delimit the solution space.(Cheng & Atlee, 2007)
- Requirements analysts start with ill-defined, and often conflicting, ideas of what the proposed system is to do, and must progress towards a single, detailed, technical specification of the system (Cheng & Atlee, 2007)
- Requirements Engineering (RE) is a multidisciplinary field that blends software engineering, systems engineering, product management, and psychology. (Ebert, 2012)

Evolution of RE - key milestones

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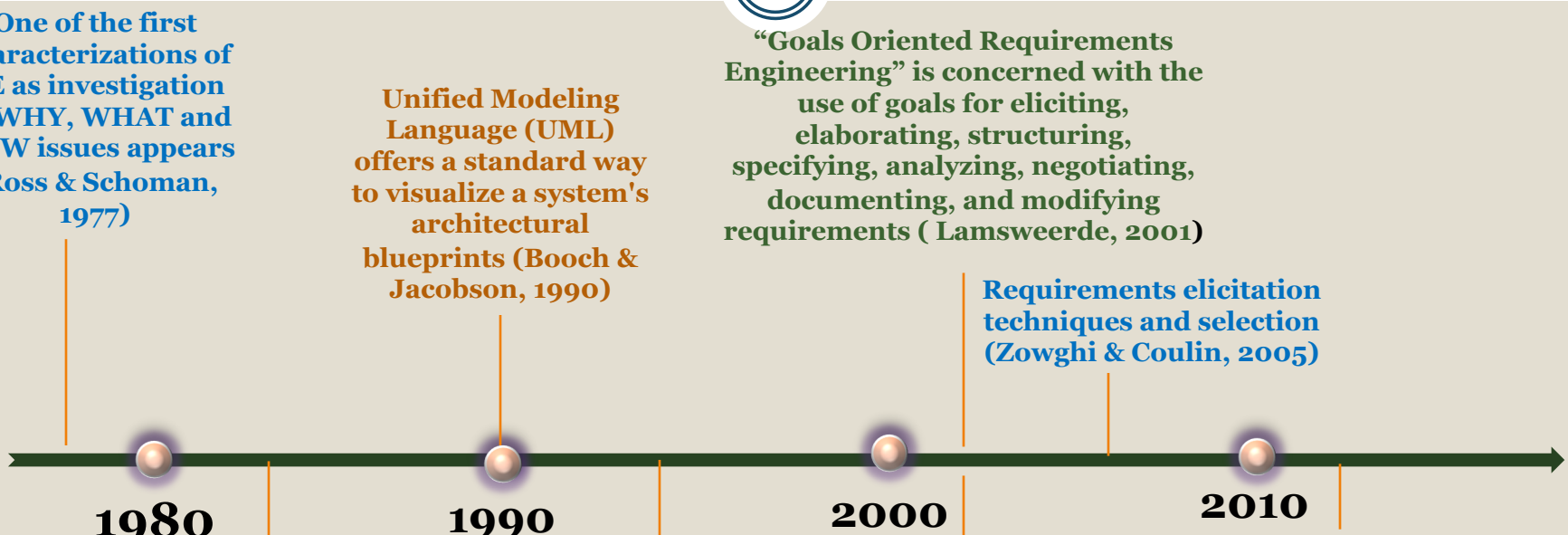

One of the first characterizations of RE as investigation of WHY, WHAT and HOW issues appears (Ross & Schoman, 1977)

Unified Modeling Language (UML) offers a standard way to visualize a system's architectural blueprints (Booch & Jacobson, 1990)

"Goals Oriented Requirements Engineering" is concerned with the use of goals for eliciting, elaborating, structuring, specifying, analyzing, negotiating, documenting, and modifying requirements (Lamsweerde, 2001)

Requirements elicitation techniques and selection (Zowghi & Coulin, 2005)

Identification of requirements based on Scenario-based prototyping (Hooper & Hsia, 1982)

Inquiry-based Requirements Analysis, which was built on Scenario based analysis, with what-if analysis embedded in it. (Potts and Anton, 1994)

Four new principle proposed:
1. Intertwine requirements and context
2. Evolve designs and ecologies
3. Manage through architecture
4. Recognize and mitigate against design complexity
(Jarke & Mylopoulos, 2011)

Agent-Oriented Modelling Framework *i**, where it allows to capture agent (role) properties such as intentionality, autonomy, sociality, contingent identity and boundaries, strategic reflectivity and rational self-interest. (Yu, 2001)

HOW
WHY
WHAT

Findings

RE is multi-disciplinary, highly social and human centric activity.		
"RE is an inherently social process, involving the contribution of individuals working in an organizational context"	Viller & Rodden, 1997	+
" The *i** modeling approach is an attempt to bring social understanding into the system engineering process by putting selected social concepts into the core of the daily activity of system analysts and designers"	Yu, Maiden & Mylopolous, 2009	+
"Building software system is a social activity"	Lim & Bentley, 2011	+
"we strongly recommend to not just consider goals of stakeholders but also social structures and strategic dependencies in initial system analysis"	Jarke, Huang & Liu, 2011	+
"Social impact is underestimated, during Req Reviews"	Salger, 2013	+

Legend: + = Reinforces the argument **- = Refutes the argument**

Findings (Contd.)

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Two primary activities of RE are : eliciting requirements and modeling & analyzing requirements, both requires communications skills and Emotional Intelligence.

"Elicitation of the knowledge category of 'unknown knowns' is difficult because of political reasons or user may be unwilling to articulate requirements because of clashes with their values and emotional reactions. Making such knowledge accessible requires the personal communication skills and emotional intelligence".	Sutcliffe & Sawyer, 2011	+
"A well-known problem in requirements engineering is the communication between stakeholders with different background"	Kaindl & Pilat, 2011	+
Major failures reasons in RE practices are: - Broken communication links between customer, analyst and developer.	Lin & Peng, 2010	+
" Communicating requirements is on the most crucial aspects of managing requirements throughout the project."	Savio & Anitha, 2012	+

Findings (Contd.)

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RE is a creative process.		
"Requirements engineering is not recognized as a creative process"	Nuseibeh & Easterbrook , 2000	-
"requirements engineering as a creative problem solving process" "enable requirements researchers and practitioners to recruit relevant theories, models, techniques and tools from creative problem solving to understand and support requirements processes more effectively"	Maiden ,2010	+
"Creativity plays an important role in generating requirements ideas"	Berry & Niknafs, 2012	+
"Creativity is very much important for requirements analysis. The practice of systematic creativity technique is needed to generate inventive ideas and to achieve better outcome in requirements engineering"	Saha & Selvi, 2012	+

Findings (contd.)

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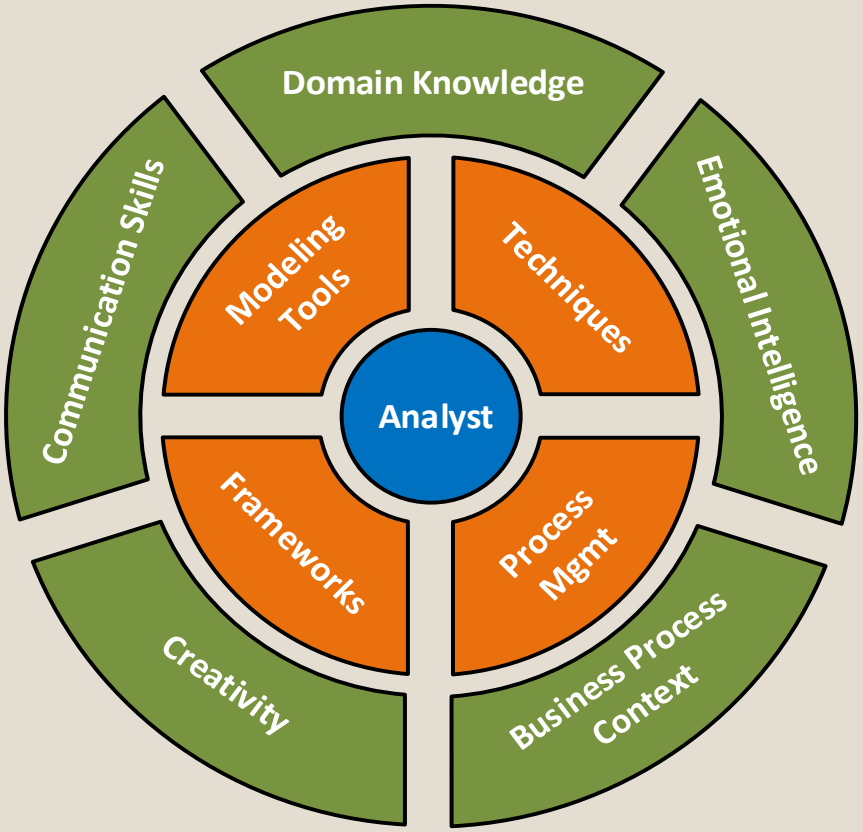
RE requires domain knowledge.		
It was demonstrated by many research contributions that the use of *domain knowledge* has positive effects on the RE task	Pohl, 1993	+
We need to understand the application domain for software development	Bjorner, 2010	+
Major failures reasons in RE practices are: - Analyst do not have access to sufficient domain knowledge and expertise.	Liu & Peng, 2010	+
"Communicating requirements without sufficient domain knowledge or understanding of the context of the requirement, gives room for misinterpreting of requirements".	Lamsweerde, 2008 Saha & Selvi, 2012	+
"Requirement Analysts who are ignorant of domain knowledge are more effective in requirements idea generation and requirements elicitation".	Berry & Niknafs, 2012	-

Conclusion



An Analyst can be equipped with Tools and Techniques, but if he lacks attributes like Domain knowledge and Interpersonal skills, the Requirements Process would not be very effective.

Thank you

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