Need for Software Design Methodology for Remote Sensing Applications

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Abstract: Remote Sensing (RS) is being widely used in many critical applications. It includes spatial information that is significant to the impression of communication, coordination, command and control in military operations. The heterogeneous and evolutionary nature of RS data adds complexity to the development process. Due to the complexity of remote sensing applications development, some systematic approach should be adopted. Software development methodology facilitates to subdivide a project to reduce the overall complexity. In this paper we have identified different characteristics of remote sensing data/applications and compared it with existing conventional software development methodologies and argue that a software design methodology suitable for this particular domain is needed.
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1. Introduction

Software development community is expanding with the advancement of information technology field. Information retrieval is done by using web applications, having reliability as an important factor. A methodology is a combination of tools and techniques providing guidance to an information system development of large scale (Shah, 2008). To address the specific organizational needs and to enhance the functional capabilities for its business growth, an efficient information system is to be developed. The development of such an information system can be done with proper planning, analysis, design and implementation (Shalom and Haan, 2006). This process is known as a System Development Life Cycle (SDLC). A purposeful framework is to be provided by the methodologies to apply some techniques and resources well in time during the software development process to measure the standards of the development process. Methodology may provide a structural framework for the acquisition of knowledge. The challenge of developing a good information system is the main issue in computer science. Due to this reason, the development of a Software Engineering Methodology is the subject of extensive research.

RSAs are used in resource management, archaeology, epidemiology, anthropology, human health condition and international relations (Ahmad and Shah, 2010; Ronald, et al., 1998). Agriculture gets its benefits from RSAs through cultural wastelands identification, monitoring of temporal_behavior of vegetation (Srinivasa, et al., 2003). RSAs play an important role in disaster management. They offer and interpret fire fuels mapped data, analyzing fire effects to monitor fire danger (Ahmad and Shah, 2010; Emilio, et al., 2003). In the same way help to design mitigation and contingency strategies for electrical outages, volcanic eruption, tornadoes, tsunami, earth quacks and hurricanes (Haddi, et al., 2003). RS data is also decisive in timely and intelligent military operation decisions (Ahmad and Shah, 2010). The precise spatial_information is vital to the notion of command and control, communication and dexterity in armed forces operations (Ahmad and Shah, 2010; Stanley, et al., 2004).

2. Related Work

Shah has proposed a framework for prototype-based software development methodologies (Shah, 2001). He proposed an Object-Oriented Design Methodology (OODM) by modifying a classical waterfall model (Shah, 2003). Ahsan and Shah have proposed a software development methodology by modifying waterfall model for one of the scientific and evolutionary domain i.e. Bioinformatics. Agile SDM's have generated a lot of interest in SE community owning to their alleged suitability for evolutionary, iterative and volatile domains such as bioinformatics and WBA's (Ahsan and Shah, 2008). However, it is not essential that a firm Agile Method (AM) suits all settings or individuals. In a comprehensive comparison of AM's, it is pointed out that little importance has been placed on analyzing the situations where AM's are more suitable than others. On the basis of their results, a new domain of applications is identified in the characteristics specifications of the domain for which AMD's are more suitable (Ahsan and Shah, 2008). The applications such as Computer Aided Construction (CAC) and the WA's belong to this set of applications or domain (Shah et al., 2009). One special characteristic of the objects of this class of applications is that these normally change their structure (methods and instance-variables), (state/data values, or both). (Shah, 2003) also added some other characteristics which are prevalent to bioinformatics and some other scientific domains, thus broadening the scope of the applications in compliance to these characteristics.

Wirfs-Brock et al and Shah suggested modification to the Spiral model and the Waterfall model to make them suitable frameworks for the object-oriented development methodologies and the prototype-based development methodologies, respectively. The strictly *static order* working of the phases was replaced by *iterative cycles* and *back cycles.* An iterative cycle meant for incorporating additional knowledge into an already developed system resulted in the processing of both design and development phases. For this reason the two phases were merged into a single development phase. A *back-cycle* is represented as an incorporating process for the revision to an under-development system. Due to these modifications, the modified life cycle model was able to consider, acquire and incorporate both the meta-data knowledge (functional requirements) and data knowledge (data instances) of the system, which were acquired at the start or during the system development of evolutionary domains.

3. Proposed Work

In this paper we have identified peculiar characteristics of remote sensing data/applications and are listed below:

- Distributed Temporally
- Spatially Categorized
- Critical Response_Time
- Temporal in nature: volatile
- Have validity constraints
- Evolutionary
- Uncertain, imprecise
- Heterogeneous
- Voluminous
- Broad Context
- Policy dependant
- Integration with society perspective
- Harmonic information

3.1 Limitations of Existing Agile Techniques

In our opinion, existing agile SD techniques despite of being used for the development of computer applications (CA) relating to evolutionary domain, have some limitations because, they are not supported by a suitable framework/methodology consisting of the characteristics of the evolutionary domain (ED), e.g. i) Explorative/iterative nature ii) Difficulty in specifying functional requirements iii) Emergent requirements. The above characteristics necessitate an iterative analysis process. Temporal aspect can be added to trace back the history of changes. To the best of our knowledge, the existing Agile SDM's such as XP, Scrum, Crystal methodologies, FDD and the RUP do not have an iterative analysis process/mechanism to store temporal information of a system. Hence, a methodology is needed having an iterative analysis process/mechanism for storing temporal information.

Table 3.1 gives some of the existing frameworks/methodologies, supporting remote sensing characteristics.

From Table 3.1, there are some frameworks and methodologies which support evolutionary type of data. But no single framework or methodology support the majority of these types of data, so there is a need for a methodology which enables to capture the evolutionary data types. Ahsan has proposed a methodology for bioinformatics which belongs to a scientific and evolutionary domain. Table 3.2 gives a comparison between the bioinformatics data characteristics and of remote sensing.

From Table 3.2, it is suggested that there is a need for domain specific methodology for remote sensing applications like bioinformatics as proposed by Ahsan and Shah (Ahsan and Shah, 2008).

4. Conclusions and Future Directions

We have identified the main characteristics of remote sensing applications and compared these characteristics not only with the conventional domains but also with a scientific and evolutionary domain such as Bioinformatics. Table 3.1 depicts that no single software development framework/methodology is available to handle all characteristics if RS data. Hence, a hybrid approach must be adopted to cater all such type of data.

Table 3.1: Frameworks/methodologies supporting remote sensing data/applications

Remote sensing Data characteristics	Methodology Factors	Methodology(s)	Framework
	Tight Control	SADT, JSD, Yourdon	Water Fall
	Measurable Progress	SADT, JSD, Yourdon, Booch, Coad & Yourdon, Shlaer & Mellor	Water Fall, Incremental, RAD
	Resources needs to be conserved	SADT, JSD, Yourdon, Coad & Yourdon, Shlaer & Mellor	Water Fall, Incremental, RAD, Spiral
Distributed-Temporally and Spatially Categorized	Online Requiring Extensive User Dialog	Shlaer & Mellor	Prototype, Incremental, Spiral
	Future Scalability of Design is Critical	Booch, coad & Yourdon	Water Fall, Incremental, Spiral
	Risk Avoidance is at high Priority	Booch, Shlaer & Mellor	Spiral
	High Degree of Accuracy	Booch, Shlaer & Mellor	Spiral
	Might benefit from mix Methodologies	Booch, Shlaer & Mellor	Spiral
	Dramatic savings in Time	XP, Scrum , Crystal	RAD
	Active user Involvement	Fusion, XP	Prototype, RAD
	Interactive	Yourdon, Coad&Yourdon, Shlaer & Mellor, Fusion	Prototype, Incremental, Spiral, RAD
	Tight fit Between User Requirements and System Specifications	SADT, JSD, XP, Scrum	Water Fall, RAD
Critical Response Time	Dramatic Saving in Time	Fusion, XP, Crystal, Scrum	Prototype, RAD
	Highly customized	Fusion, Booch, XP	Spiral, Prototype, RAD
	High Degree of Accuracy	Booch, Shlaer & Mellor	Spiral
	Highly Skilled and experienced Manager required	Fusion, Booch, Shlaer & Mellor, XP,	Prototype, Spiral, RAD
	Clear Objectives	SADT, JSD, Yourdon, Booch, Coad & Yourdon	Water Fall, Incremental, Spiral
	Flexible Control	Fusion, Booch, Coad & Yourdon, Shlaer & Mellor, XP, Scrum	Prototype, Spiral, RAD, Incremental
	Requirements may Change Significantly	Fusion, Booch, Shlaer & Mellor	Prototype, Spiral, RAD
	Experienced Project Manager	Fusion, Booch, Shlaer & Mellor	Prototype, Spiral, RAD
	Risk Avoidance is a high Priority	Fusion, Booch	Spiral
	A High Degree of Accuracy	Fusion, Booch	Spiral
Temporal in Nature: Volatile	Progress of System Development is Measurable	SADT, JSD, Yourdon, Booch, Coad & Yourdon, Shlaer & Mellor,XP	Water Fall, Incremental, RAD
	Documentation Required	SADT, JSD, Yourdon, Booch, Coad & Yourdon, Shlaer & Mellor	Water Fall, Incremental, Spiral
	Project has Clear Objectives and Solutions	SADT, JSD, Yourdon, Booch, Coad & Yourdon, Shlaer & Mellor	Water Fall, Incremental, Spiral
	Requirements are Stable	SADT, JSD, Yourdon, Booch, Coad & Yourdon, Shlaer & Mellor	Water Fall, Incremental
Have a Validity Constraints	User is Involved Throughout the System Development	Fusion, XP	Prototype, RAD
	Pressure Exists for Immediate Implementation of Something	Fusion, XP	Prototype, RAD
	Low Project Risk	Fusion, Booch	Spiral
	A high Degree of Accuracy	Booch, Shlaer & Mellor	Spiral
	Experienced Team Members	Fusion, Booch, Shlaer & Mellor	Prototype, Spiral, RAD
	Possible Project Division	SADT,Yourdon, JSD, Fusion, Shlaer & Mellor, Booch, Coad & Yourdon	Water Fall, Prototype, Incremental, Spiral
	Documentation not needed	Fusion, Booch, XP, Scrum	Prototype RAD
Evolutionary	Flexible Sequence Control	Fusin, Booch, Coad & Yourdon, XP	Prototype, Spiral, RA Incremental
	Requirements may Change Significantly	Fusion, Booch, Shlaer & Mellor, Scrum	Prototype, Spiral, RAD,
	Experienced Team Members	Fusion, Booch, Shlaer & Mellor	Prototype, Spiral, RAD
	Encourage Innovation and Flexible Design	Fusion, Booch, Shlaer & Mellor, Coad & Yourdon	Prototype, Incremental, RAD
Uncertain, Imprecise	Project Objectives are Unclear	Fusion, Booch, Shlaer & Mellor, Scrum	Prototype, RAD

	Functional Requirements may change Frequently and Significantly	Fusion, Booch, Shlaer & Mellor, Scrum	Prototype, Spiral, RAD
	Online System Requiring Extensive User Dialog	Yourdon, Coad & Yourdon, Shlaer & Mellor, Fusion	Prototype, Incremental, Spiral
	Flexible Control	Fusin, Booch, Coad & Yourdon, XP	Prototype, Spiral, RAD, Incremental
	Project Manager is Highly Skilled	Fusion, Booch, Shlaer & Mellor	Prototype, Spiral, RAD
	Rapidly Change ability to the System Design as Demanded by users	Fusion, Booch, Shlaer & Mellor, Scrum	Prototype, Spiral, RAD
Heterogeneous	Unstable Team Composition is and predictable to Fluctuate	SADT, JSD, Yourdon, Booch, Shlaer & Mellor	Water Fall, Incremental
	Encourage Innovation and Flexible Design	Fusion, Booch, Shlaer & Mellor, Coad & Yourdon	Prototype, Incremental, RAD
	Project Decomposition	SADT,Yourdon, JSD, Fusion, Shlaer & Mellor, Booch, Coad & Yourdon	Water Fall, Prototype, Incremental, Spiral
	Flexible Control	Fusin, Booch, Coad & Yourdon, XP	Prototype, Spiral, RAD, Incremental
	Mixture of other Development Methodologies	Booch, Shlaer & Mellor	Spiral
	Requirements of the System are Unknown or Uncertain	Fusion, Booch, Shlaer & Mellor, Scrum	Prototype, Spiral, RAD
Voluminous	Project Division	SADT,Yourdon, JSD, Fusion, Shlaer & Mellor, Booch, Coad & Yourdon	Water Fall, Prototype, Incremental, Spiral
	Measurable Progress	SADT, JSD, Yourdon, Booch, Coad & Yourdon, Shlaer & Mellor	Water Fall, Incremental, RAD
	Difficult to Respond Changes	SADT, JSD, Yourdon, Booch, Coad & Yourdon, Shlaer & Mellor	Water Fall, Spiral
	Project is Large, Expensive and Complicated	SADT,Yourdon, JSD, Fusion, Shlaer & Mellor, Booch, Coad & Yourdon	Water Fall, Prototype, Incremental, Spiral
	Mainframe or Transaction Oriented Batch Systems	SADT, Yourdon, JSD	Water Fall
	Avoid to Solve Wrong Problems	SADT,Yourdon, JSD, Fusion, Shlaer & Mellor, Booch, Coad & Yourdon	Water Fall, Incremental, Spiral
	Technical Requirements (e.g. Response Time, Throughput) are Reasonable.	XP, Scrum, Crystal	RAD
	Continual Evolution of the Project Requirements	Fusion, Booch, Shlaer & Mellor, Scrum	Prototype, Spiral, RAD
	Reduce Project Risk by Breaking Project into Smaller Segments	Booch, Shlaer & Mellor	Spiral
	Encourage Innovations and Flexible Changes	Fusion, Booch, Shlaer & Mellor, Coad & Yourdon	Prototype, Incremental, RAD
	Team Members are Fully Experienced	Fusion, Booch, Shlaer & Mellor	Prototype, Spiral, RAD
	Very Large Infrastructure Projects	SADT,Yourdon, JSD, Fusion, Shlaer & Mellor, Booch, Coad & Yourdon	Water Fall, Prototype, Incremental, Spiral

Table 3.2: Difference between biological and remote sensing data characteristics

Factors/Criteria	Biological Data	Remote Sensing Data
Volatility of Data	Volatility Results from new findings and environment	Volatility results from need and application
Source of Change	Evolution is Research based (experiments in the Wet-lab.)	Evolution is Observation and Need based
Source of Uncertainty	Uncertainty results from different experimental Procedures	Uncertainty results from equipment used
Interaction with Society	Need not be integrated (indirectly) with society perspectives	Need to be integrated (directly) with society perspectives
Data Generation Source	Primary Data generation sources are centralized	Primary data sources are Distributed
Location of data	It is generated in Lab.	It is generated through Geospatially (out of the Lab.)

Generation	environment	
Decision/Use	It is not used for real time decisions	It is used for real time decisions
Cause of Imprecision	Imprecision results from faulty or non-standardize Wet-lab. equipment	Imprecision results from faulty or non-standardize Wet-lab. Equipment in addition to Environmental /Weather conditions
Granularity	Extreme level of Granularity	Moderate level of granularity
Observations	New observations are unprecedented	New Observations are precedential up-to some extent
Interval of change	Discrete	Continuous
Interval of Data Generation	Discrete	Continuous

To best of our knowledge no software development methodology is reported in literature for remote sensing applications. So, there is need to have a methodology for remote sensing applications development. We are actively working on proposing a methodology for remote sensing applications. The automation of such methodology and its working on some case studies will be carried out in future.

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