A Fuzzy Based Approach for Estimating Agility of an Embedded Software Process

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Overview

- Defining Agility
- Need for Agility
- Some observations during implementation of agile techniques
- Development of New Agile Design Methodology
- Measuring Agility
- Conclusions

Agility: Key Requirement for RPD

Rapid Prototype Development Challenges are characterized by huge amounts of uncertainty and risk. Situations are dynamic and unpredictable.

***Agility** is the ability of the Process to successfully cope with changes in requirement*

e.g.

- change in specifications

maintain acceptable level of
- performance,
- effectiveness,
- efficiency

requires

- Timely completion
- Faster response

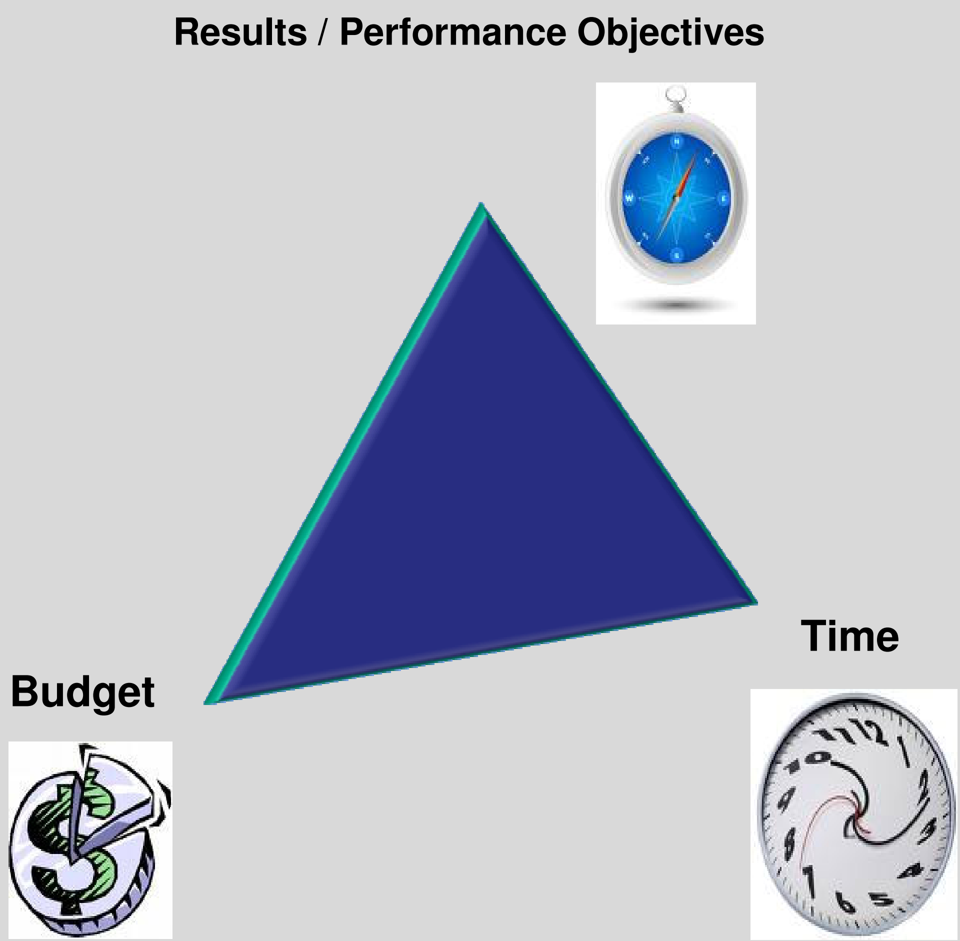
Essence of Agility: Agile Capabilities

- Being agile requires **BOTH** the ability to, in a timely manner
  - recognize a relevant change in requirement
  - respond appropriately

- Being agile includes one or more of the following

Adaptability	Requisite variety
Flexibility	Nimbleness
Responsiveness	Innovativeness
Survivability	Learning
Resilience	Tolerance
Robustness	Re-configurability
Reflexive	Re-engineering

Key Drivers



Why do we need to be agile ?

- Global Competition is intensifying.
- Mass markets are fragmenting into niche markets.
- Cooperation among companies is becoming necessary, including companies who are in direct competition with each other.

Why do we need to be agile?

- Customers are expecting:
  1. Volume products
  2. High quality products
  3. Custom products
- Very short product life-cycles, development time, and production lead times are required.
- Customers want to treated and individuals

Need for Agility

- Extensive Documentation
- Process Driven Methodology
- Puts Immense pressure on Developers
- Long Cycle time

Need of Agility

- Rigid Platform
- Needs a large team to deliver
- Skipping Deadlines
- Expensive Business Models
- Stricter Avionics Standards

Need for Agility

- Market Demands
- Faster Time to Market
- Fast Reaction to changing specifications
- Smaller Teams

Need for Agility

- Shorter Deliver Cycles
- Less Confusion between Engineers and Customers
- Lesser cost of Development
- “Commissioned Yesterday instead of tomorrow”

Need for Agility

- Has shown beneficial impact on quality , process , cost and development cycle
- Has resulted in better customer /user satisfaction levels
- Creates dynamic environment for rapid reaction to changing client specifications
- Platforms are more stable ,secure and inter-operable

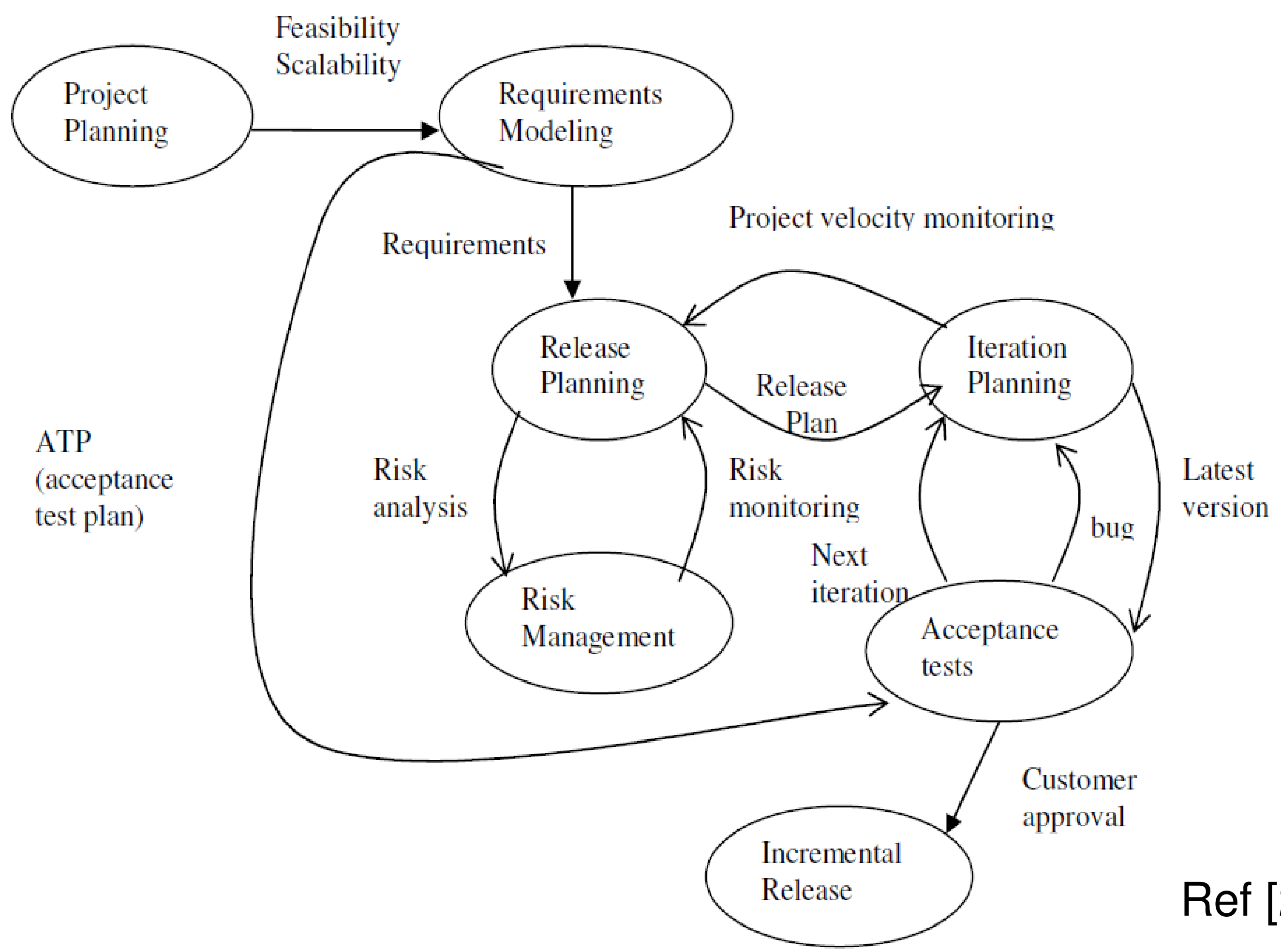
Some observations during implementation of agile technique

- Numerous Methods are available on web
- Difficult to choose a good method
- Expert Guidance not readily available
- No standardized method to measure the agility

Development of New Agile Design Methodology

- Developed an agility process called RAADM Ref[2]
- RAADM uses the combination of XP and DSDM Ref[2]
- Difficult to measure agility

RAADM Process Model



Ref [2]

Essence of Agility: Measuring Agility

- Developing an operational definition of agility requires being able to measure the degree to which something is agile.
- A quantitative definition is desirable

Project Velocity and Agility Attributes

- Agility Metrics can be modeled using Project Velocity

- This velocity is resultant of two components

  - ✓ P_{v1} : Project Velocity without Requirement Changes

  - ✓ P_{v2} : Project Velocity Estimated when a Requirement change occurs

Project Velocity and Agility Attributes

- ✓ Only Incremental changes occur
- ✓ No major changes in the main base line
- ✓ Experience of domain experts necessary
- ✓ Domain Experts foresee the level of changes that might occur

Assumptions

Project Velocity and Agility Attributes

- ✓Domain Experts classify those modules as probable risk modules
- ✓Domain experts are also able to estimate the risks due to team configuration
- ✓Code modularizing necessary
- ✓Thereby tests required for any change is greatly reduced
- ✓ This makes process is adaptable

Project Velocity and Agility Attributes

- F(x) denotes estimates in man –days required for finishing the release when no requirement changes occur
- Let F(y) denote Estimate in Man Days required for finishing the release when requirement changes occur

(1) Ref [3][4]

- ✓ $P_{v1} = \frac{d\,F(x)}{dt}$
- ✓ $P_{v2} = \frac{d\,F(y)}{dt}$

Parameters that contribute P_{v1}

- Technical Complexity (TC)
- Documentation
- Programmer Capability(PC)
- Risk Impact(RI)
- Testing (T)
- Deadline (DL)

Parameters that Contribute to measure of P_{v2}

- Technical Complexity (TC)
- Documentation (D)
- Programmer Capability(PC)
- Risk Impact(RI)
- Testing (T)
- Deadline (DL)
- Requirement Change (RC)

Fuzzy modeling of the agile process

- A fuzzy rule relating input variables xi denoting the parameters TC,PC,RI,T,DL,RC can be written
- Their linguistic values $A_n^{\sim p}$ has values *'low, medium ,high'*
- $A_n^{\sim p}$ can be related to the term project velocity P_{vj}

Fuzzy modeling of the agile process

- The rule base can be written as

  ✓ *IF* $x_1^{\sim}$ *is* $A_1^{\sim p}$ *and* $x_2^{\sim}$ *is* $A_2^{\sim p}$ *AND…* $x_n^{\sim}$ *is* $A_n^{\sim p}$ *THEN* $P_{vj}(xi)$ *is* B_j *(2) Ref [3] [4]*

where

The consequence of the rule B_j is a crisp value.

- $B_j = \sum_{i=1} b_i x_i + c_j$ *(3) Ref [3][4]*

- For a given rule , b_i denotes the weight and c_j represents the bias value

- The variable $x_i = x_1 .. x_n$ denotes the set of parameters like TC,PC,D etc.

- The project velocity $P_{vj}(x_i)$ will be

$$P_{vj}(x_i) = \frac{\sum_{j=1}^{m} w_j * B_j}{\sum_{j=1}^{m} w_j} \qquad (4) \qquad \text{Ref: [3],[4]}$$

- Here, w_j is the firing strength of each rule and 'm' is the number of rules.

Fuzzy modeling of the agile process

- Similar rule sets can be written for $P_{vj}(yi)$
- yi represent the input variables when requirement change occurs.
- As $P_{vj}(xi)$ and $P_{vj}(yi)$ represent two disjoint values which are additive

- A crisp estimate for project velocity can be done
- Project velocity P_{v1}, P_{v2} can be computed using (2), (3) and (4).
- Hence , the overall project velocity is given by

$$P_v = \frac{\sum_{i=1}^{2} P_{vi} * t_i}{\sum_{i=1}^{2} t_i} \qquad (5) \qquad \text{Ref [3] [4]}$$

Fuzzy modeling of the agile process

- Here i has values from 1 to 2, in the present study .
- P_{vi} denotes the project velocity components and has two values P_{v1} and P_{v2}
- The variable t_i represents the time interval for which the P_{vi} is calculated

Fuzzy modeling of the agile process

- In (5) P_{vi} is a signed value
- Thus the overall project velocity P_v can decrease or increase
- This increase or decrease variation is based on the extent of requirement change
- Project velocity 'P_v' gives a measure of agility.

Selection of Input Ranges for P_{V1} & P_{v2}

- Input Ranges are selected by proper analysis & design
- Experience of the Domain Experts is very useful
- Domain Experts in selection of the range of the inputs

Selection of Input Ranges for P_{V1} & P_{v2}

- From experience it can be seen that PC,TC,D,DL,T,RI can always have a value which has a positive offset from ZERO

- Referencing to a standard project necessary

  - ✓ It is possible to arrive at a set of values for the above parameters

  - ✓ A ratio estimate

Input Ranges for P_{v1}

Attributes for P_{v1}	Ranges for P_{v1}
PC	[0.5 1]
TC	[0.2 1]
D	[0.3 1]
DL	[0.2 1]
T	[0.4 1]
RI	[0.3 1]

Input Ranges for P_{v2}

Attributes for P_{v2}	Ranges for P_{v2}
PC	[0.5 1]
TC	[0.2 1]
D	[0.3 1]
DL	[-1 1]
T	[0.3 1]
RI	[0.2 1]
RC	[0.3 1]

Implementing the Fuzzy Model

- The sugeno inference system modeled in MATLAB FUZZY TOOL BOX
- The membership functions were chosen as gaussian membership function
- Choosing a triangular membership function did not bring any significant change in output

Implementing the Fuzzy Model

- The Sugeno model for P_{v1} has 6 inputs and a rule base of 72 rules
- The Sugeno model for P_{v2} has 7 inputs and a rule base of 54 rules
- These rules are formulated based on experience of domain experts in handling similar projects.

Implementing the Fuzzy Model

- The membership functions mf_i that facilitate in determining P_{v1} and P_{v2} are set as linear type
- Weights for P_{v1} and P_{v2} are set as 1
- Their linear coefficients b_i are set equal to 0.5 and $c = 0$

Implementing the Fuzzy Model

Attributes for P_{v1}	Inputs for P_{v1}
PC	0.75
TC	0.48
D	0.63
DL	0.30
T	0.80
RI	0.47

Implementing the Fuzzy Model

Attributes for P_{v2}	Inputs for P_{v2}
PC	0.75
TC	0.60
D	0.65
DL	0.08
T	0.80
RI	0.60
RC	0.50

Implementing the Fuzzy Model

- Sugeno Inference Engine calculated P_{v1} =8.39
- Sugeno Inference Engine calculated P_{v2}=1.94
- For the project under study , the total project period t is 90 days

Implementing the Fuzzy Model

- Requirement change occurred after 75
  - So t1=75 days
  - t2=15 days
  - $P_v = 7.315$
- Agility factor A_F is directly proportional to the Project Velocity
- $A_F = K P_v$

Implementing the Fuzzy Model

- The value of k is assumed as 1
- It was found that requirement changes brings some impact on agility
- In the simulation study only one time the requirement change occurred
- But often it is seen that during development process customers frequently request for requirement change

Implementing the Fuzzy Model

- Similarly the values of TC,PC,D have higher sensitivity to the evaluation of P_{v1}
- TC, PC, RC and DL which offer a major sensitivity on the P_{v2}
- Optimization is therefore necessary to control overall agility
- Since parameters also can vary with time it may be necessary to optimize these parameters to maximize agility

Conclusions

- Proposes a novel method for quantitative estimation of the agility
- Uses the parameter *‘project velocity’*
- The proposed method envisages a fuzzy knowledge based model to measure agility

Conclusion

- An important aspect of this study is that this modeling has been done based on the statistical data and expertise available from domain experts

- Has also revealed that the dependence of some of the input parameters on agility is more significant than others
- A topic of future research will be optimizing the agility based on the input parameters

References

1. Tsourveloudis,Nikos;Phillis,Y.A.,1998, "Manufacturing flexibility Measurement: A Fuzzy Logic Frame Work", *IEEE Transactions on Robotics and Automation* Vol 14 no4 pp513-524.
2. Kurian ,Tisni ,2005," Agility in IT : Creating Software through Agile Techniques ".*Proceedings of the IEI-International Conference on Agility Design and Manufacturing(ADEMSE-05),*Bangalore ,India
3. Kurian ,Tisni, 2006, "Agility Metrics: A Quantitative Fuzzy Based Approach for Measuring Agility of a Software Process" *IEE- ISAM-Proceedings of International Conference on Agile Manufacturing'06(ICAM-2006)*, Norfolk, U.S.A
4. Kurian ,Tisni , Poonacha ,K.M , Raghu G.S ,2007 ,'SIPL –Agile Estimator : A design Approach to Fuzzy-Based Software for Estimating Agility",*International Journal on Agile Manufacturing,*Volume 10 , Issue 2.
5. Poonacha,K.M;Kurian, Tisni;Bhattacharya,Subir,2010;" Metric for Measuring Agility ", *PGDCM Thesis Report,I.I.M-Calcutta* ,India.
6. Charlene A. Yauch, (2011) "Measuring agility as a performance outcome", *Journal of Manufacturing Technology Management*, Vol. 22 Iss: 3, pp.384 - 404

Thank You