NII Shonan Meeting, Oct 21, 2014

Generalized Software Reliability Model (GSRM)

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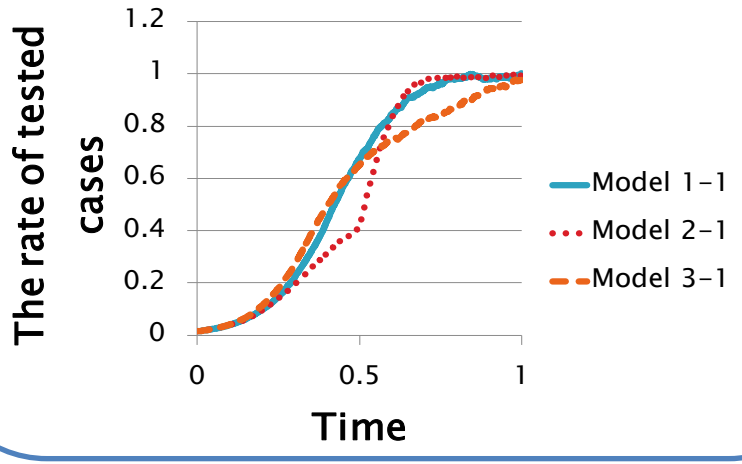
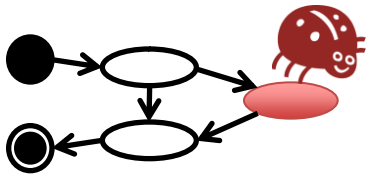
Kiyoshi Honda, Hironori Washizaki, YoshiakiFukazawa, “A Generalized Software Reliability Model Considering Uncertainty and Dynamics in Development,” PROFES 2013

Background: Testing and Reliability

- Empirical
  - Bug Localization in Industry [ICST'14]
  - Testing in OSS [PROFES'14]
- Web and Ajax
  - Gray Box Testing [FASE'13]
  - Mutation Testing [SEKE'13]
  - State-Machine Extraction and Verification [ASE'13][ASE'14]

- Software Reliability Model [PROFES'13]

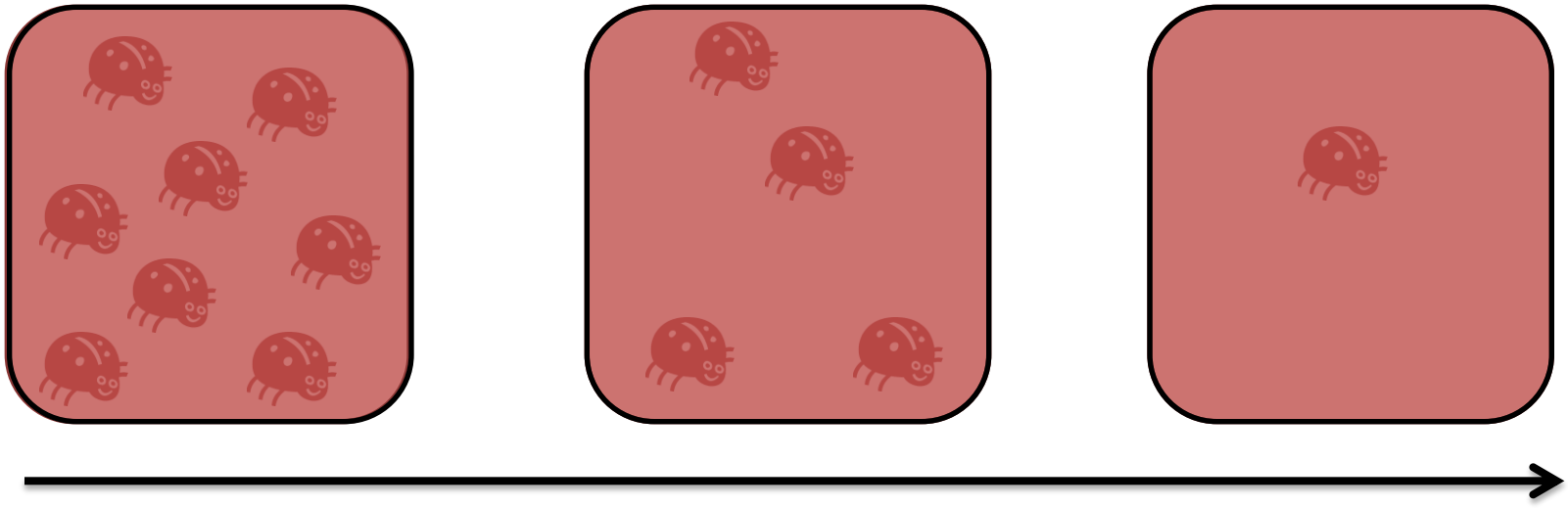




Semi-automatic Incompatibility Localization for Re-engineered Industrial Software, ICST'14
Do open source software projects conduct tests enough?, PROFES'14
Mutation Analysis for JavaScript Web Applications Testing, SEKE'13
Automated Verification of Pattern-based Interaction Invariants in Ajax Applications, ASE'13
Validating Ajax Applications Using a Delay-Based Mutation Technique, ASE'14
A generalized software reliability model considering uncertainty and dynamics in development. PROFES'13

Motivation

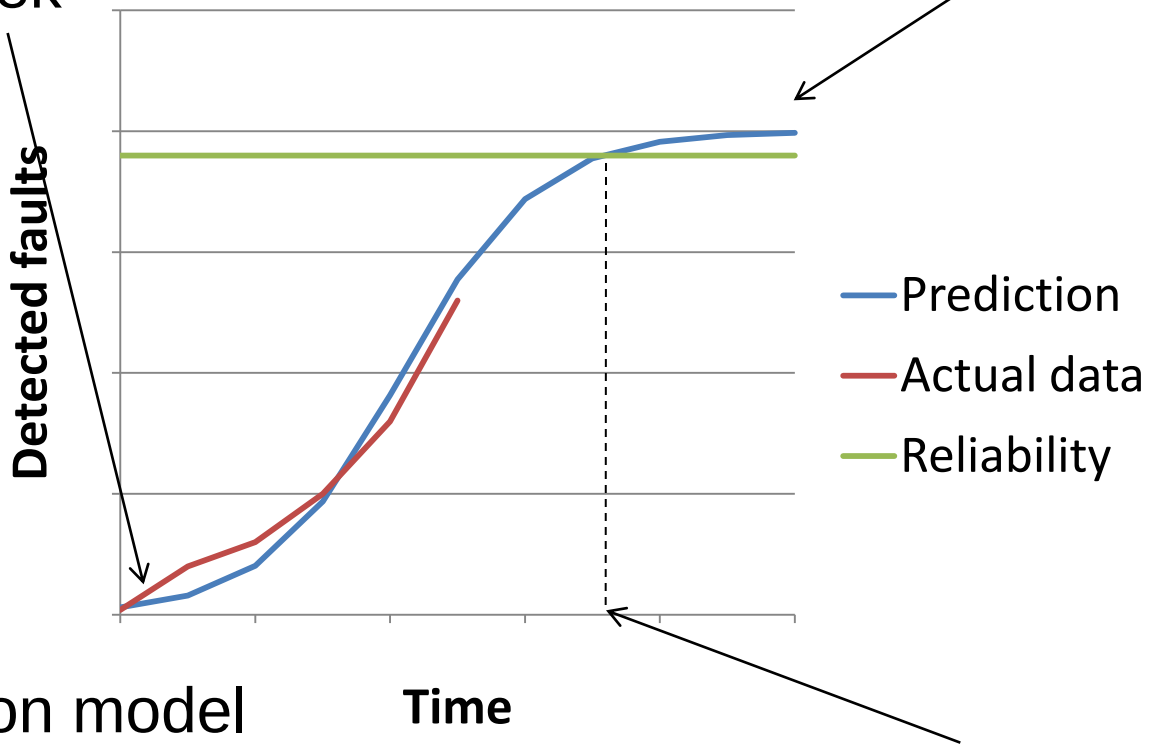
- When can we release software?
- How many efforts are necessary for further testing?



Software Reliability Model (SRM)

Approximate actual data to a curve and predict defects

Counting the defects a day or a week



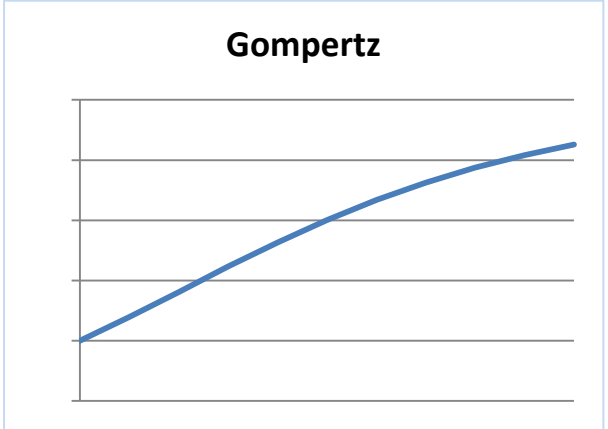
Prediction model

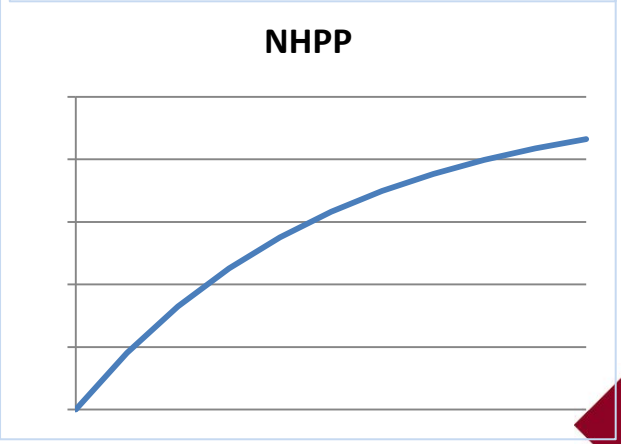
$$N(t) = \frac{N_{max}}{1 - \exp(-at)}$$

At this time, 95% of all defects will be found

Types of SRM

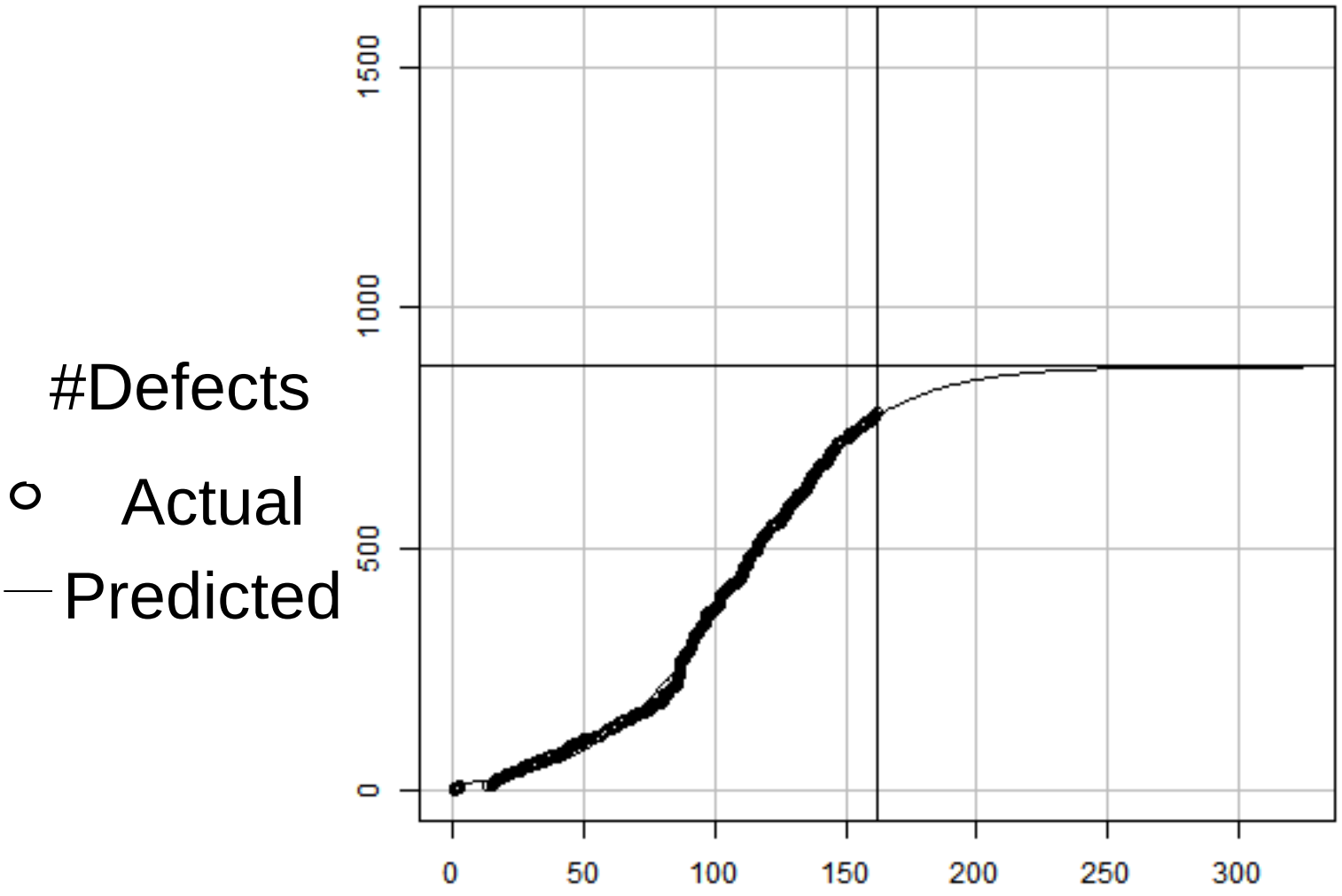
- Statistic analysis model
  - From actual data approximate to a curve.
  - Gompertz model
  - Logistic model
- Stochastic process model
  - The detection of defects follows stochastic process
  - Non-homogeneous Poisson process(NHPP) model [Goel]





[Goel] A.L. Goel and K. Okumoto *A non-homogeneous poisson process model for software reliability and other performance measures*, 1979

Case (Industry)



Further Challenges in SRM

- Uncertainty
  - Actual projects have many uncertain elements which cause defects.
  - E.g. changes of specifications
- Dynamicity
  - Actual projects have some time dependency.
  - E.g. changes of developers

Idea: Generalized SRM

- Conventional Logistic Model

$$\frac{dN(t)}{dt} = (a + bN(t))N(t)$$

- Assumptions
  - Number of defects that can be found is variable depending on time.
  - Number of defects that can be found contains uncertainty, which can be simulated with Gaussian white noise.

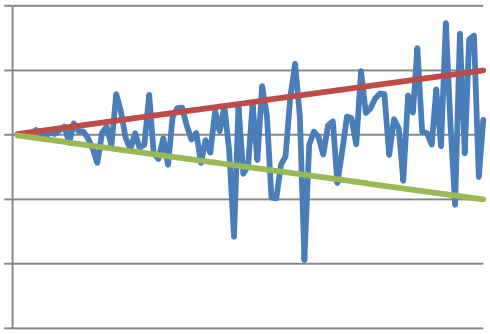
Dynamicity

Uncertainty

$$a = \alpha(t) + \sigma dw(t)$$

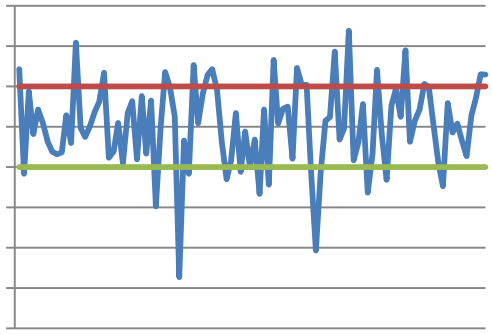
$$dN(t) = (\alpha(t) + \sigma dw(t) + \beta N(t))N(t)dt$$

Uncertainty



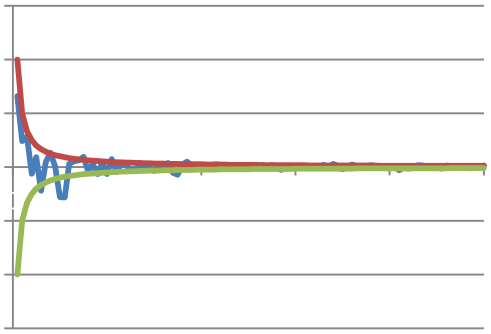
$$\gamma(t) = N(t)\sigma dw(t)$$

The uncertainty increases near the end.



$$\gamma(t) = \sigma dw(t)$$

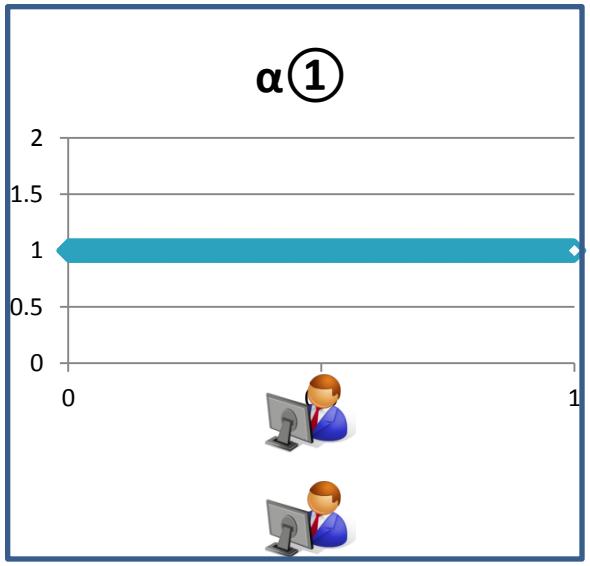
The uncertainty is constant at any given time.

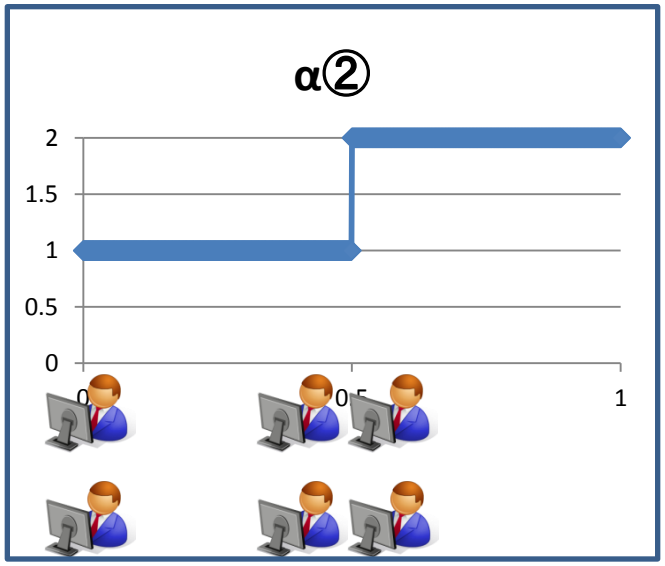


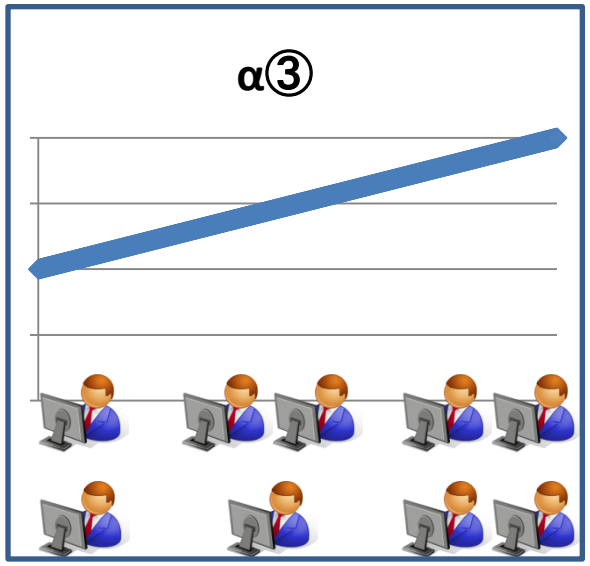
$$\gamma(t) = \frac{1}{N(t)}\sigma dw(t)$$

the uncertainty is greater at the start of the project than at the end.

Dynamicity





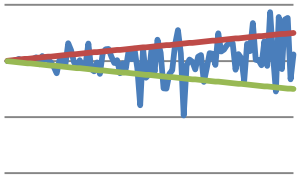
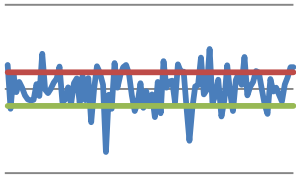
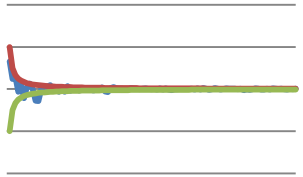
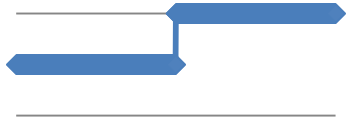


The number of developers is constant.

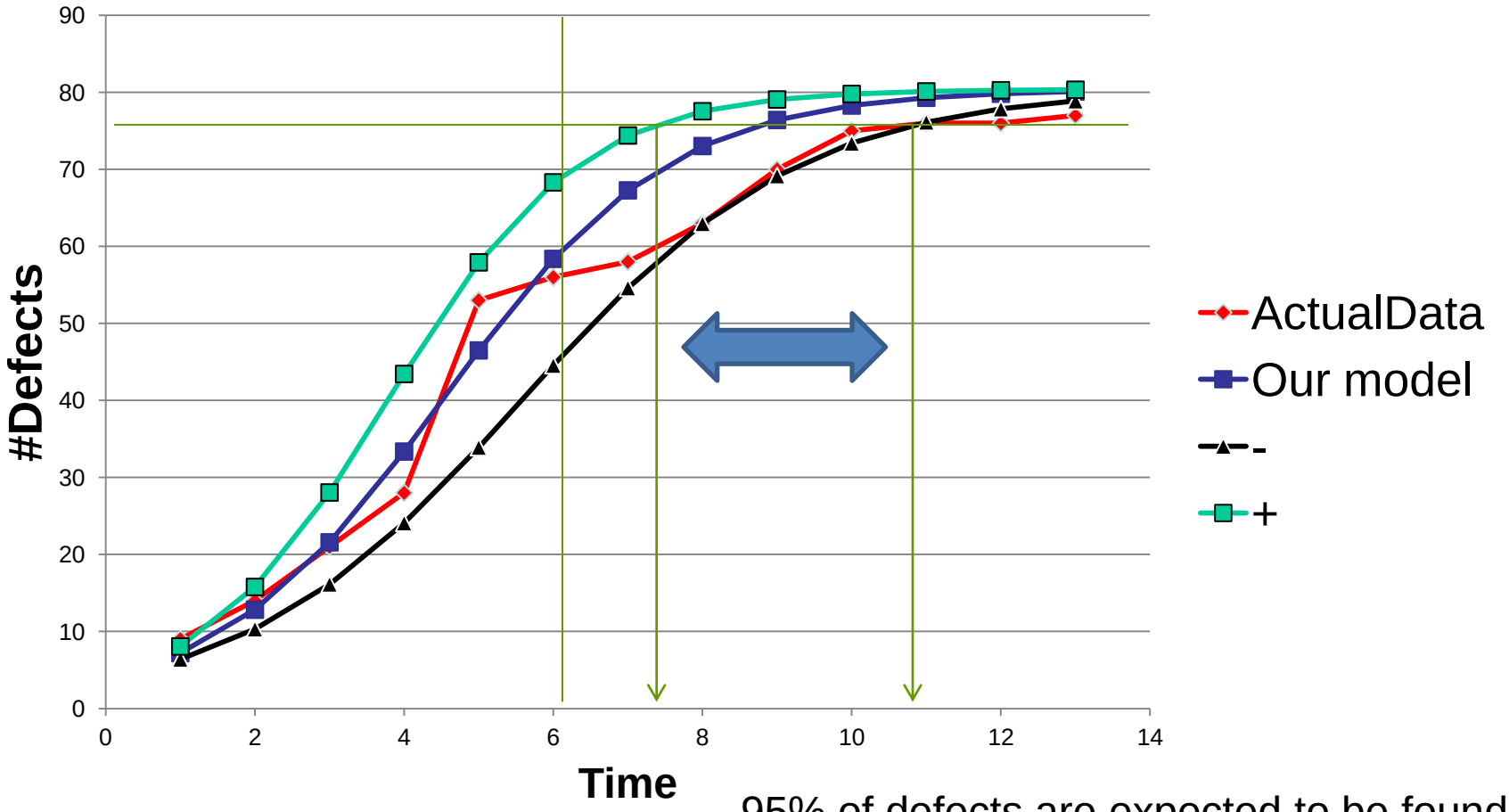
The number of developers per unit time changes at a certain time.

The number of developers per unit time increase near the end.

Combination of Uncertainty and Dynamicity

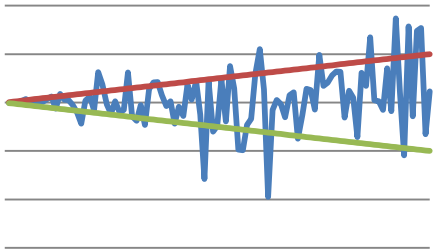
			
α① 	Similar to a logistic curve	Constant	
α② 			
α③ 			

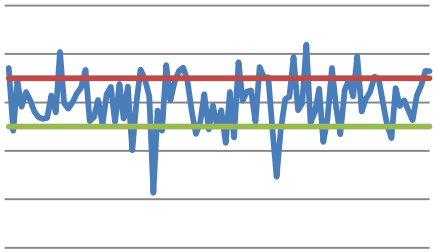
Prediction with Probability

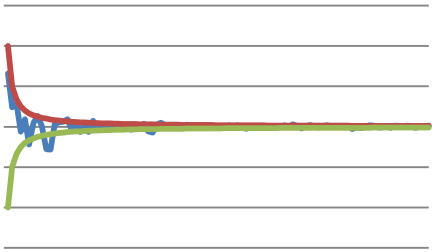


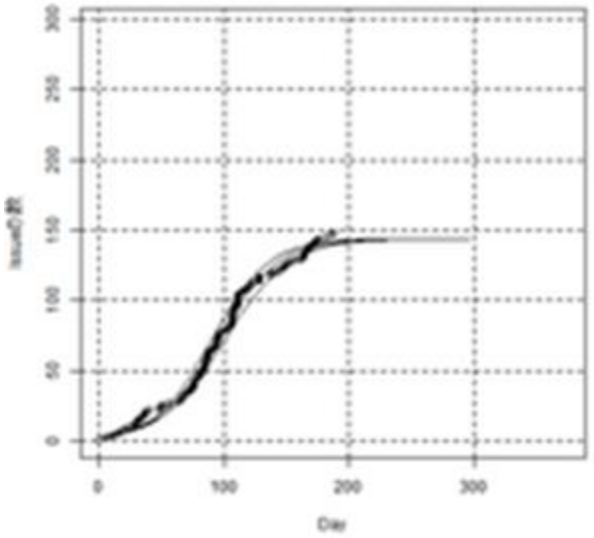
95% of defects are expected to be found during this term.

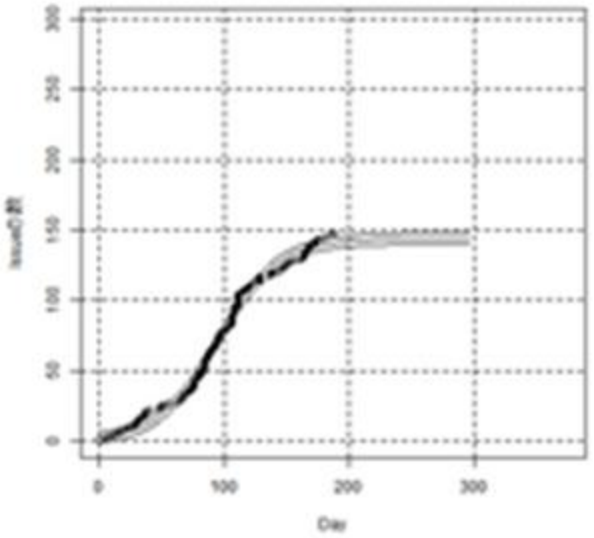
Visualization integrated with Continuous Integration Tool

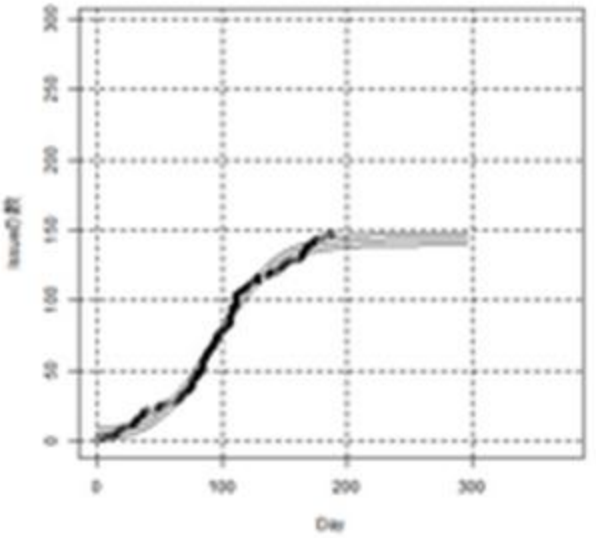






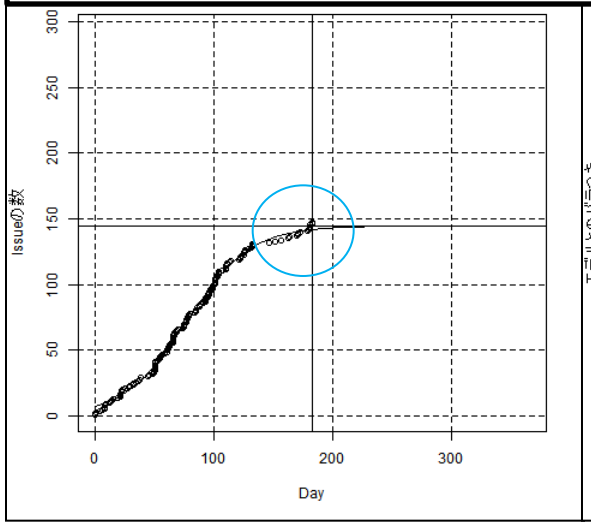


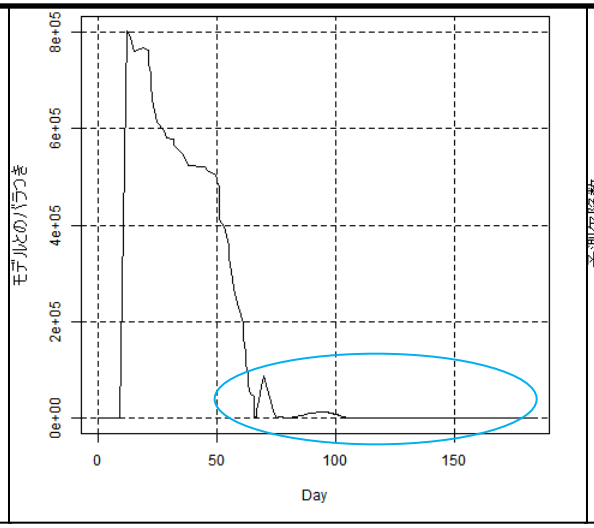


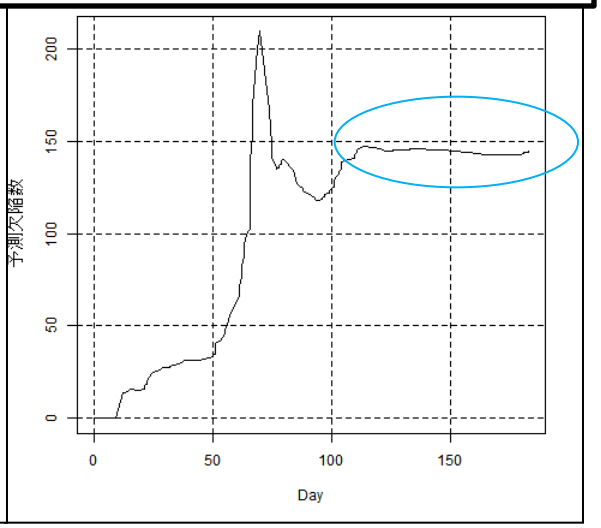


Case (Industry)

#Defects	Predication Error	#Predicted Total Defects



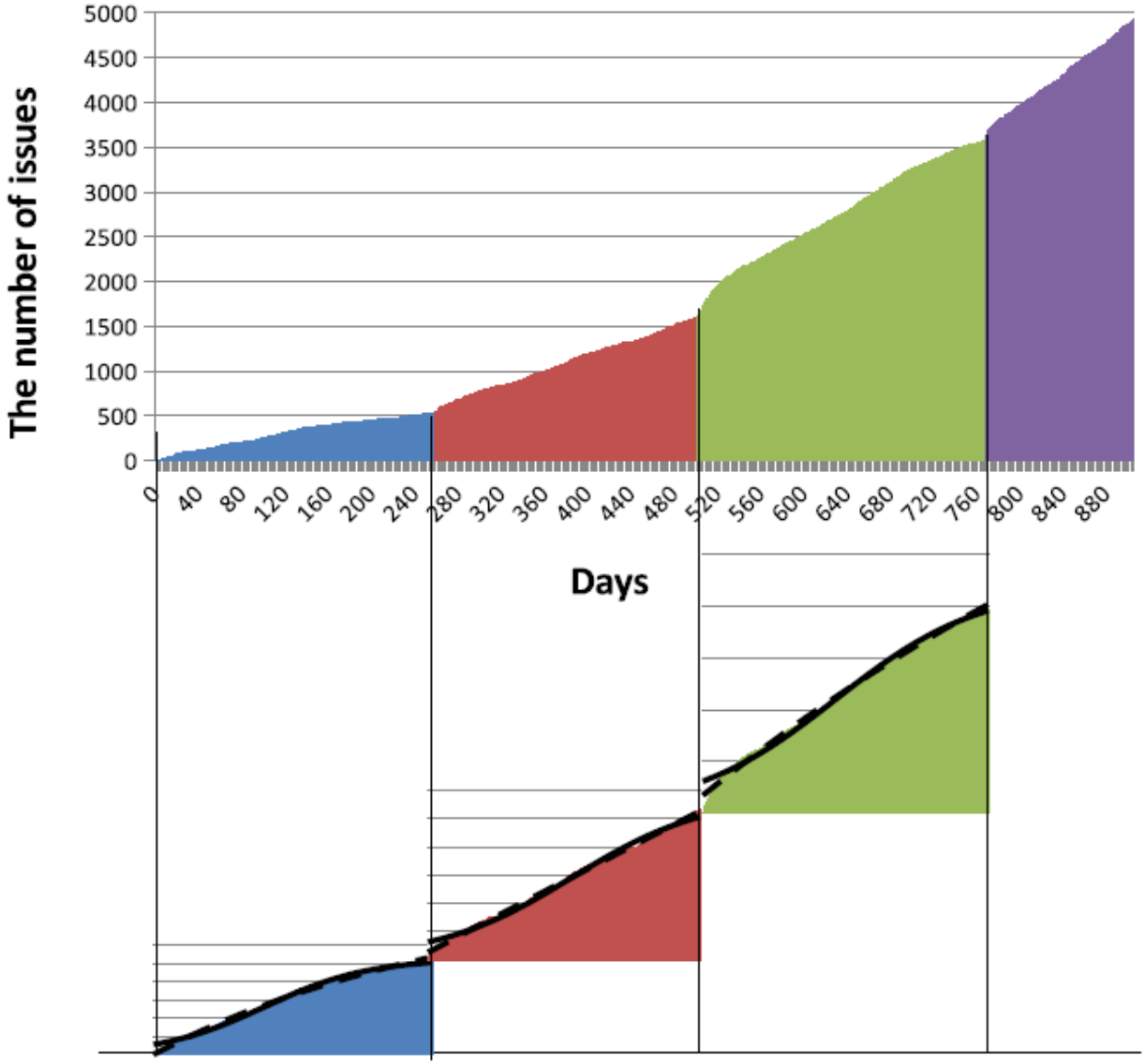




Module	Current	Predicted Total	Predicted Current	Predicted End Day
XYZ	147	144	134	156

Almost all defects seem to be detected.
Now more debugging rather than testing.

Case (OSS)



Kiyoshi Honda, Hironori Washizaki, Yoshiaki Fukazawa, “Predicting the Release Time Based on a Generalized Software Reliability Model (GSRM),” COMPSAC’14

Open Research Questions

- How to Predict Uncertainty and Dynamicity?
- How to dynamically adapt prediction?
- Can we integrate testing and debugging techniques with (G)SRM?
- Any relations among Predicted Reliability and other measures such as Testing Coverage and Mutation Testing Scores?