Japan Advanced Institute of Science and Technology
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Towards Objective Estimations of Software Implementation Progress

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1. Motivation and Goal
2. Background and Related Work
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Motivation

- Software implementation progress is often measured subjectively by software developers or project managers
- Such reports are often open to misconception leading to inaccurate schedule estimations, which is considered as one of the major causes of schedule slippage.

Goal

To devise a methodology to estimate software implementation progress objectively and timely

A Use Case Based EVA Approach

"Monitoring software projects with earned value analysis and use case points", Jinhua Li et al., 7th IEEE/ACIS International Conference on Computer and Information Science, 2008

What?

They propose the use of "Use Case Points" (UCP) and Earned Value Analysis (EVA), in order to consistently express project baselines and measure technical progress of software projects

How it works?

- A project is estimated in terms of dollars and UCPs
- Then every use case of the system is also valued in UCP and easily translated into dollars.
- Earned Values (EV) assignment: task begins ⇒ 50% of the task budget is earned, task is completed ⇒ 100% of the budget is earned

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Team: 1 mentor, 3 students
System: Automobile Rent system
*Time: **20 weeks***
*Total cost of the System: **$4500***
*12 Use cases with a total of **75 UCP***

WBS ELEMENTS	% BUDGET
Management	10.00%
Requirements	15.00%
Design	20.00%
Implementation	30.00%
Assessment	25.00%

Mentor cost: $30 per hour
Student cost: $ 50 per hour
Two iterations

• In order to plan and measure the progress in conventional way, they converted the EV of completed UCP into dollars:

$**4500**/**75** UCP = **$60** per UCP

• Since the management activity (communication and coordination) spreads over the whole project life cycle, its cost is distributed averagely. The EV (management) of one completed UCP is:

$60 * **10%** / **20** weeks **=** $0.3

• Student 'A' reported in a performance record sheet that the design and test data for use case "X", which worths 6 UCP, is finished. The EV of this work is, because it is completed 100% of:

6 UCP * **20%** * $60 + Share Management Cost =

$72 + ($0.3/**3 students**) = $72.1

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Conclusion

- This approach offers a more objective baseline measure to monitor and report progress consistently using UCP and EVA.
- Yet, to assess how much has being earned during the development of the software is rather subjective:
  - *based on formulas reporting only 50% or 100% progress. (50% at starting time and 100% at completion time)*

CK Degree of change used for Tracking and Software Development Progress

The Use of Product Measures in **Tracking Code Development** to Completion within Small to Medium Sized Enterprises, M.P. Ware, F.G. Wilkie, M. Shapcott, N.G. Lester Sixth Intl. Conf. On SW Eng. Research, Management and Applications

What?

They suggest the use of eight product measures to assist project managers to track change and progress within a release and to determine readiness

How?

- By applying Phase Analysis, monthly measurements of eight product metrics were taken through two major releases cycles and a beta release of a commercial C++ application.
- The Chidamber and Kemerer metrics were considered among the selected eight product metrics.
- The measures represent degree of change from one month to another

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Their results

- 83% of classes showing profound change, also showed a period of consolidation
- They indicate that if a developer is reporting his/her task near completion , but the measures do not show the class stabilizing, the project manager should not take the assurances at the “face value”
- They conclude that the measures used are potential useful indicators of project progress during the release cycle.

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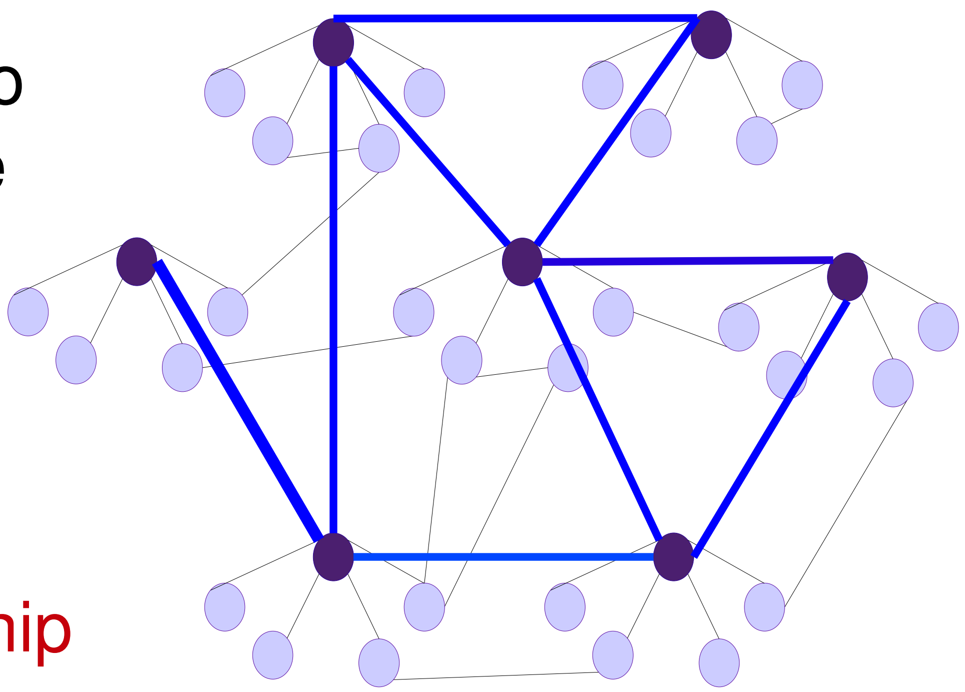
Conclusion

- Although the suggested measures can help to monitor implementation progress and can be useful to support near completion reports from developers,
- accurate and objective measures of implementation progress at any point in time are not available.

Introduction

- Metrics that probably can be used cannot be assess prior to the completion of the software (e.g. SLoC).



- A software is meant to accomplish certain specific functionalities, which are achieved trough the relationship of its various components

- If the most important components and their relationships are detailed in UML diagrams, they could be measured and used as a baseline to monitor implementation progress

What?

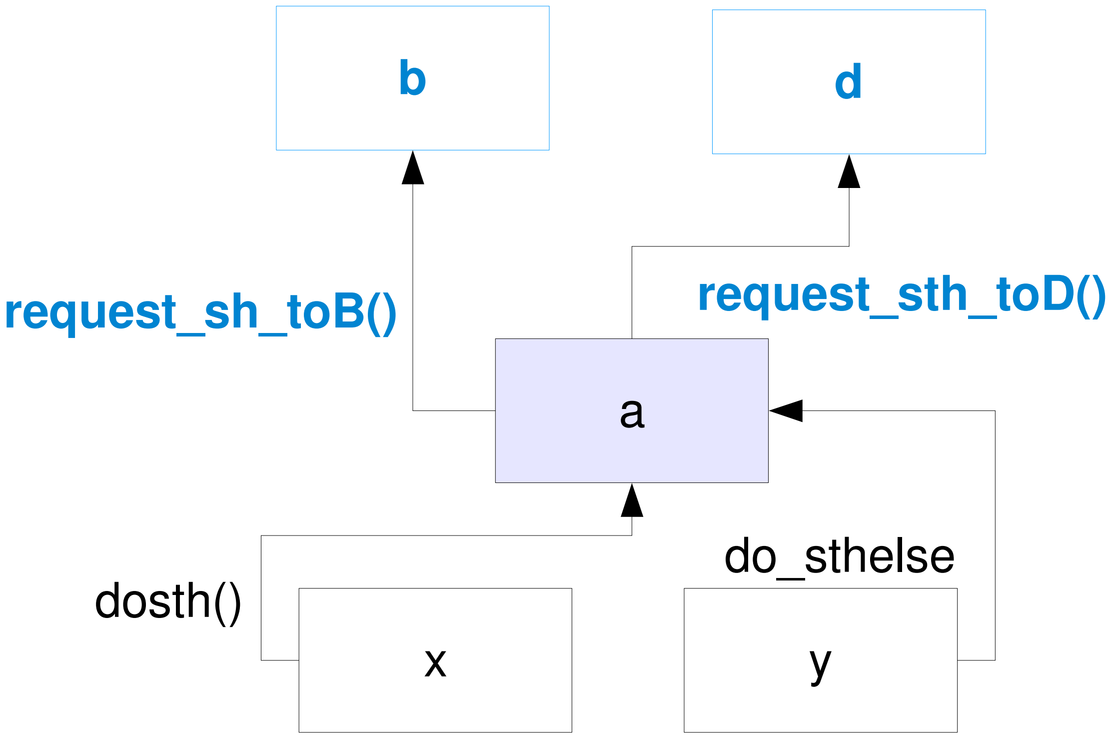
We propose a methodology to estimate and monitor software implementation progress based on CBO measures:

- CBO measures Coupling Between Objects
- A UML approximation of the final value of CBO of the system can be obtained prior to the implementation
- CBO can be systematically measured at any point in time from code repositories
- CBO has been suggested as potential useful indicator of project progress

UML CBO

```
Class A{
        B b;
        void dosth(){
                int flag;
                flag = b.request_sh_toB();
        }
        int do_sthelse(){
                int status = 0;
                int temp;
                temp = d.request_sth_toD();
                if(a>0) status = 1;
                return(status);
        }

}
```



- ***Code CBO (A)***
  Number of the different classes couple to class A, CBO (A) = 2
- ***UML CBO (A)***
  Number of the different objects which receive any message from any object of class A, UCBO (A) = 2

UML CBO Evaluation

- We collected code CBO measures of four small-size software projects developed by students of JAIST: BNS-A, BNS-B, ECS-A, ECS-B (*)
- UML CBO measures were collected from the collaboration diagrams detailed in [1]
- Using normalization, we found that UML CBO measures closely approximated their respective code measures at the end of the implementation

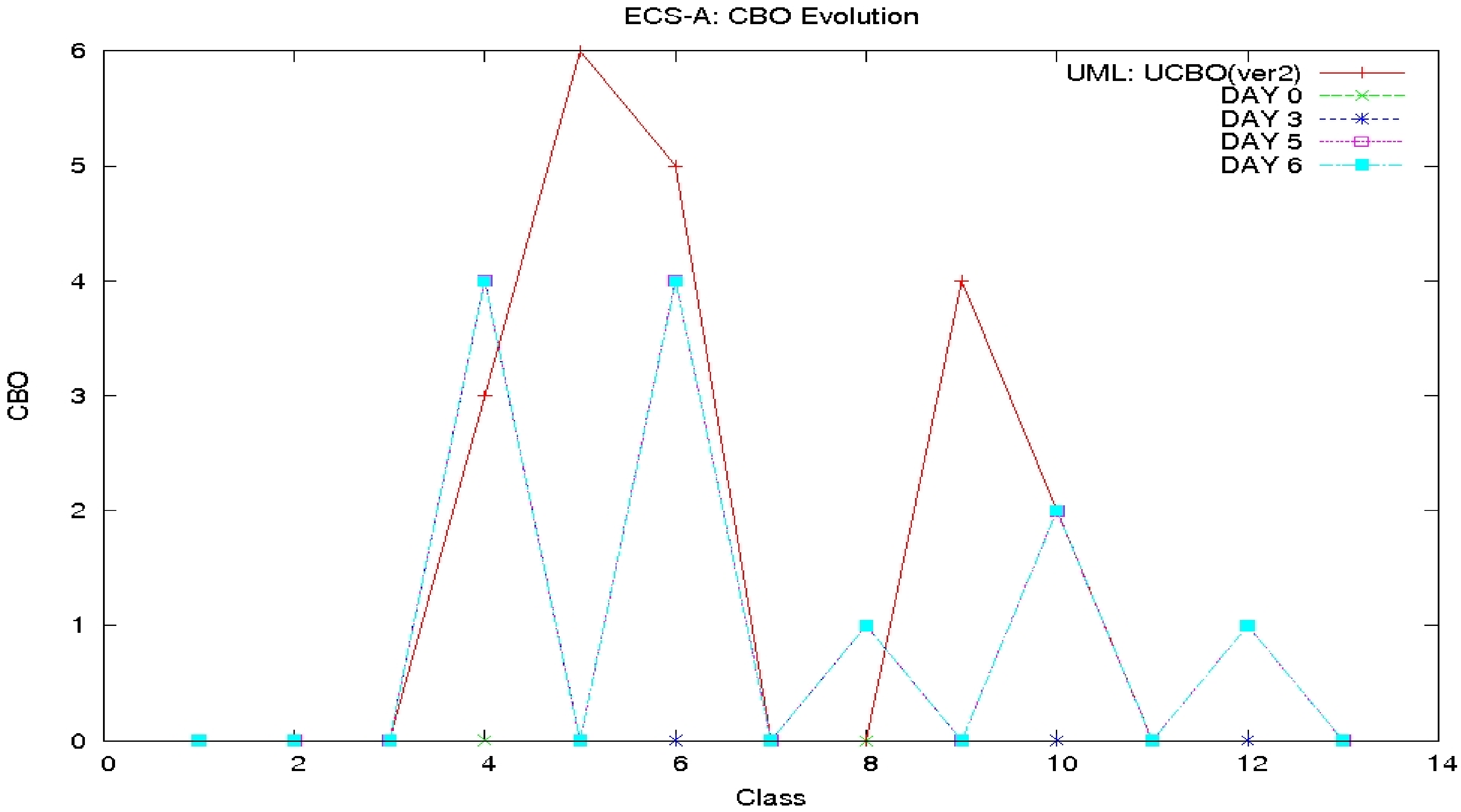
Average Absolute Errors: 0.18, 0.26, 0.11 and 0.09 for the BNS-A, BNS-B, ECS-A and ECS-B respectively

(*) ECS-A, ECS-B: Are two different implementations (A and B) of an e-commerce system developed by two different groups of students of JAIST
BNS-A, BNS-B: Are two different implementations (A and B) of a banking system developed by two different groups of students of JAIST

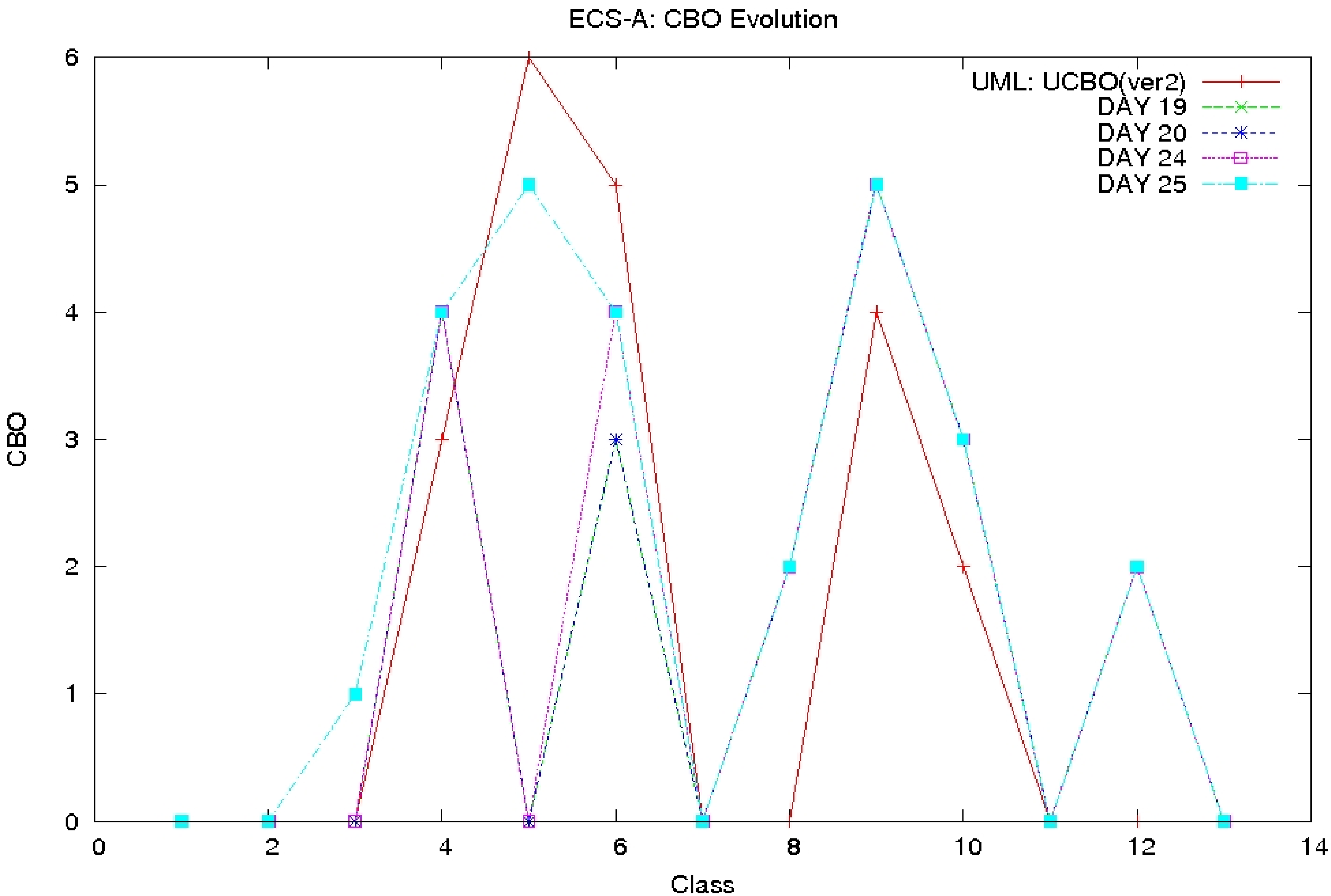
[1] Gomaa Hassan, "Designing Concurrent, Distributed, and Real-Time Applications with UML", Addison Wesley-Object Technology Series Editors, July 2000.

CBO Code Evolution vs UML CBO

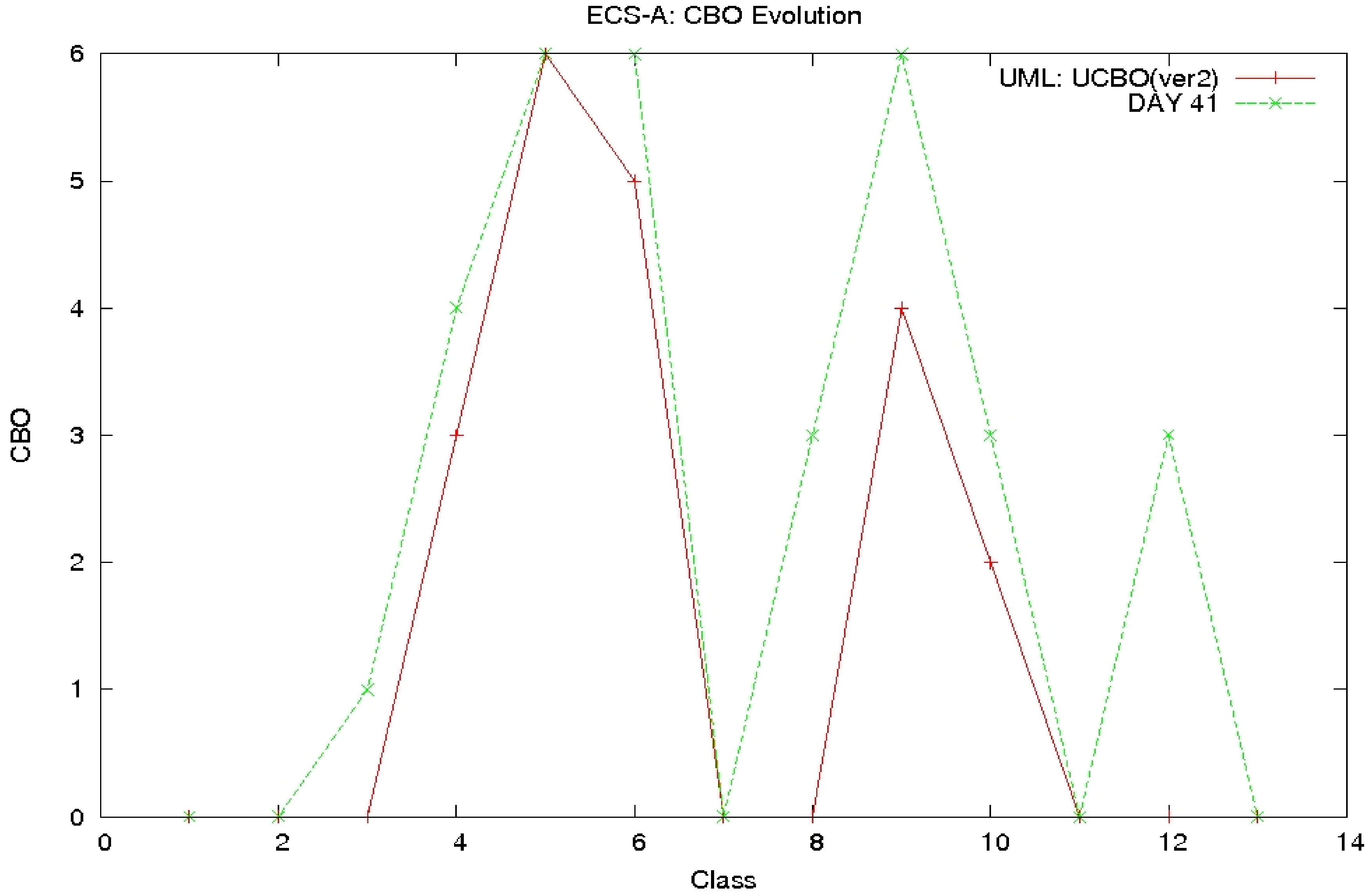
Moreover, we collected code CBO measures from the same projects FROM the day the project started TO the day was completed and contrasted them with their respective UML CBO measures.



CBO Code Evolution vs UML CBO

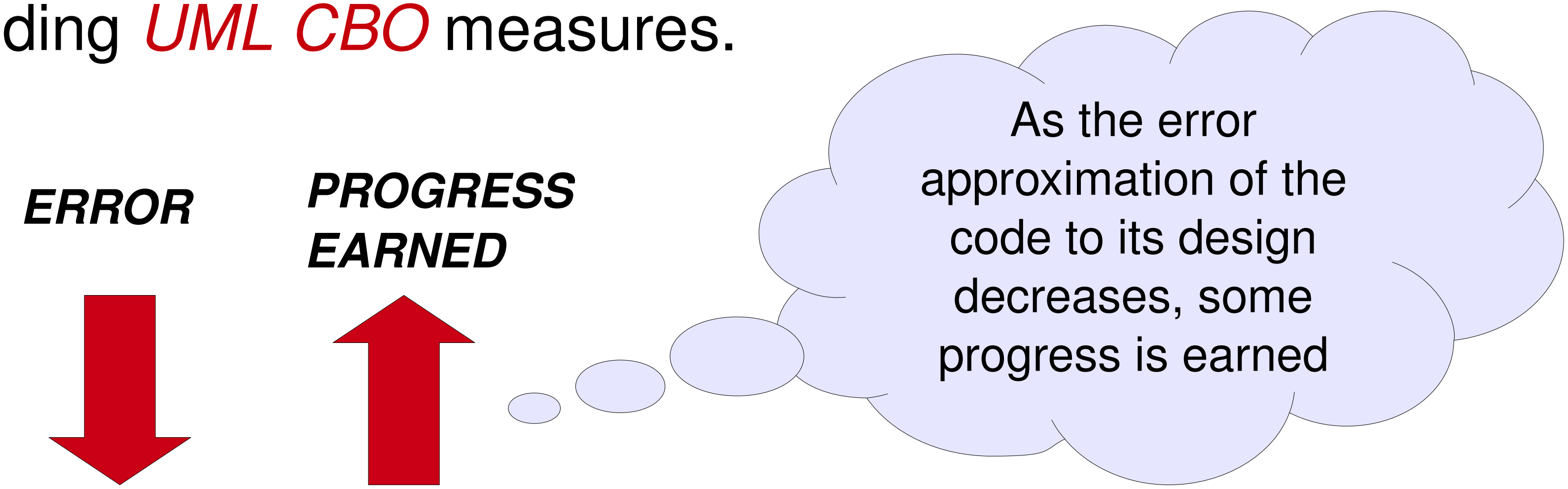


CBO Code Evolution vs UML CBO



How To Measure Progress?

- We observed that as the software development was progressing, its CBO code metrics closely approximate to their respective UML metrics.
- Therefore, to measure progress, we suggest an approach based on *normalization* and *error* approximations of the *code CBO* measures of the classes of the project to their corresponding *UML CBO* measures.



How To Measure Progress?

- STEP 1. UML CBO measurement for the all classes (N) of the project:

  UCBO [j], j=1 ... N

- STEP 2. PRODUCT VALUES of each class is measure as follows:

$$PV[j] = \frac{UCBO[j]}{\sum UCBO[j]}$$

- STEP 3. Normalization of UML measures: NUCBO[j]
- STEP 4. Code CBO measures at *Time i* (Ti): CBO_Ti[j]
- STEP 5. Normalization of code measures: NCBO_Ti[j]
- STEP 6. Calculation of Error Approximation at Ti:

  ERROR_Ti[j] = NUCBO[j] - NCBO_Ti[j]

How To Measure Progress?

- STEP 7. Earned Progress Assignation at Ti

  IF ERROR_Ti[j] >= 0.71 THEN

    EP_Ti[j] = 0;

  IF ERROR_Ti[j] >= 0.5 and ERROR_Ti[j] < 0.71 THEN

    EP_Ti[j] = 0.1 * PV[j];

  IF ERROR_Ti[j] >= 0.31 and ERROR_Ti[j] < 0.5 THEN

    EP_Ti[j] = 0.5 * PV[j];

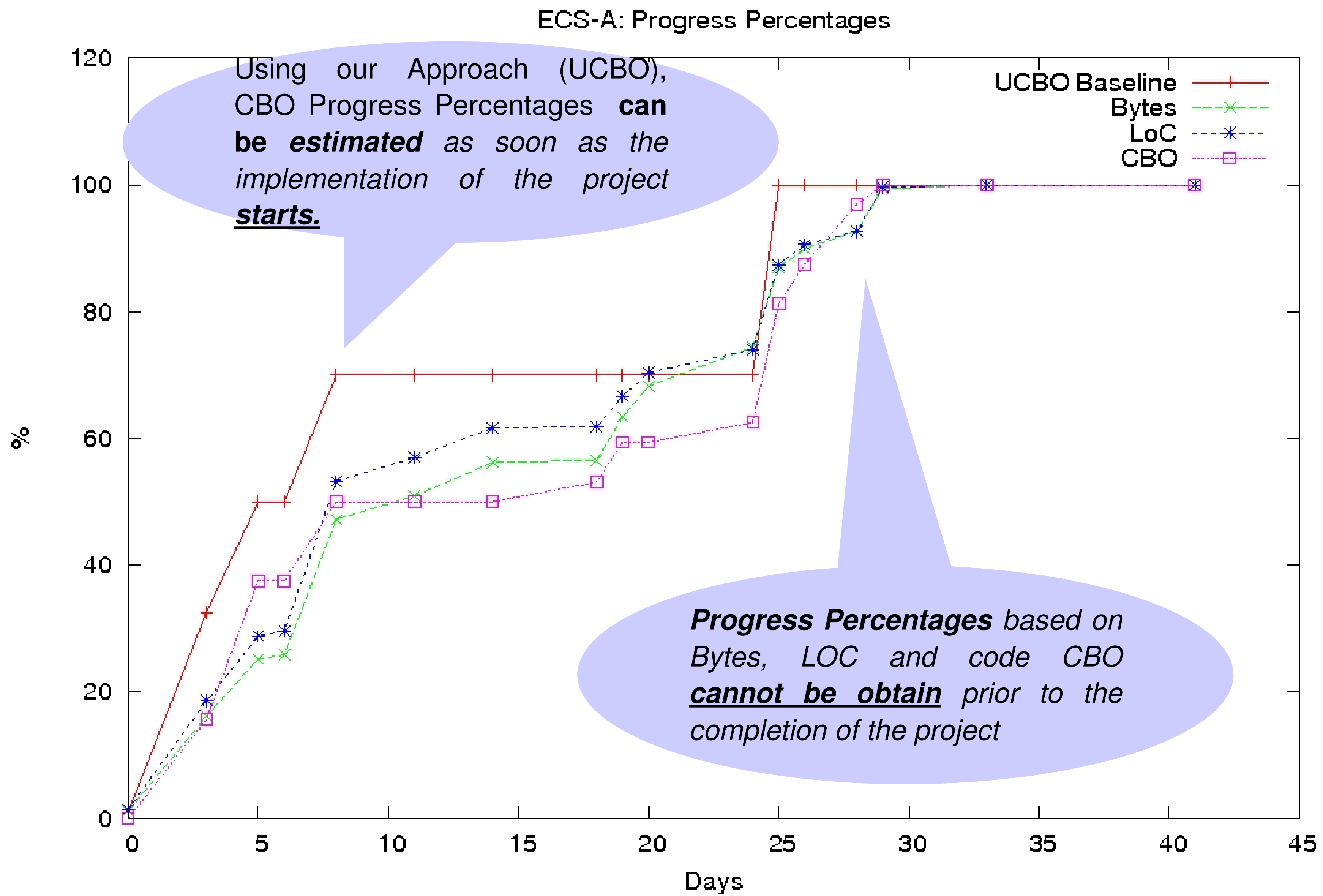
  IF ERROR_Ti[j] < 0.31 THEN

    EP_Ti[j] = PV[j];

- STEP 8. Assessment of Implementation Progress

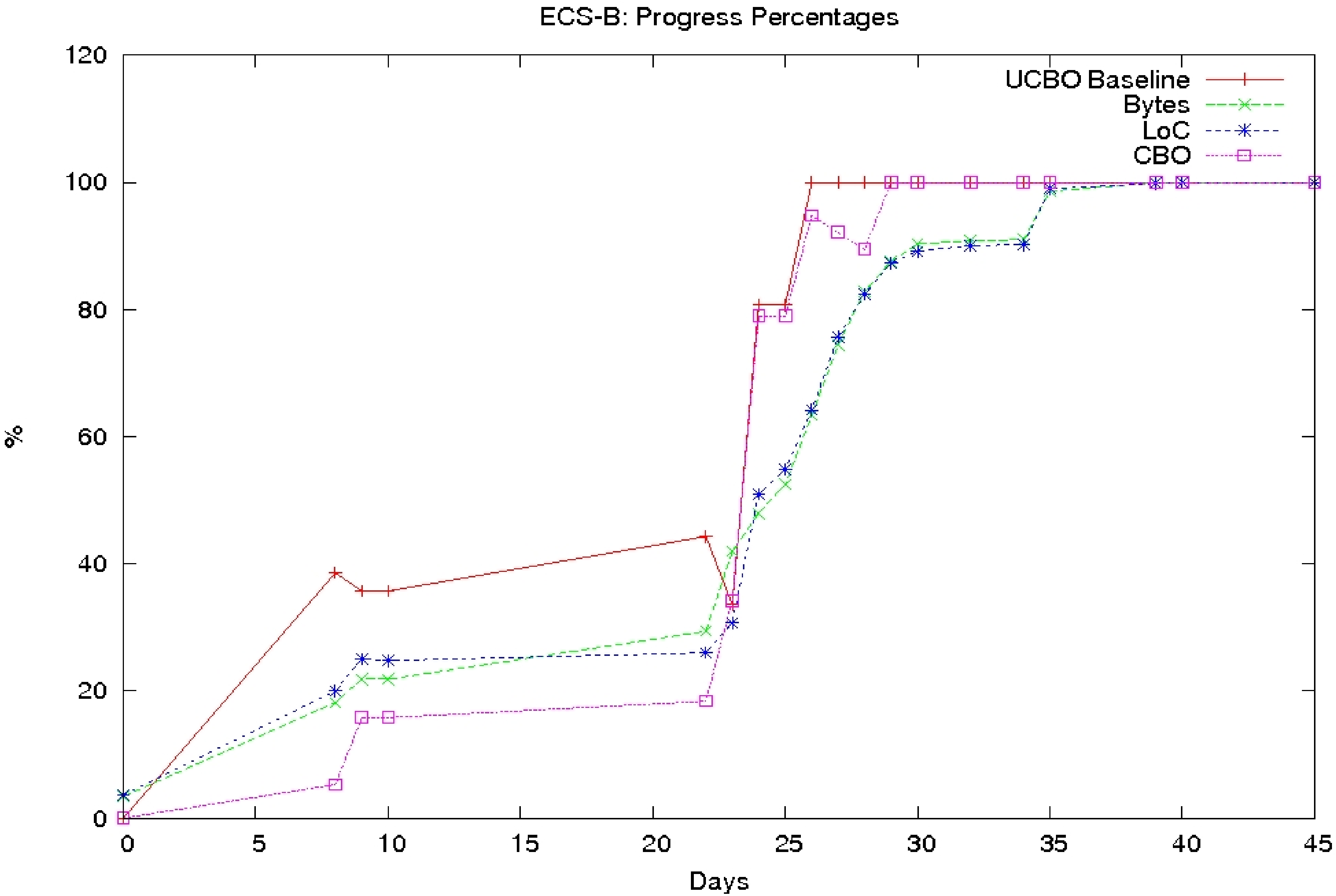
  Total Progress at Time i = ∑EP_Ti[j] * 100

Progress Percentages Patterns



Results

Progress Percentages Patterns



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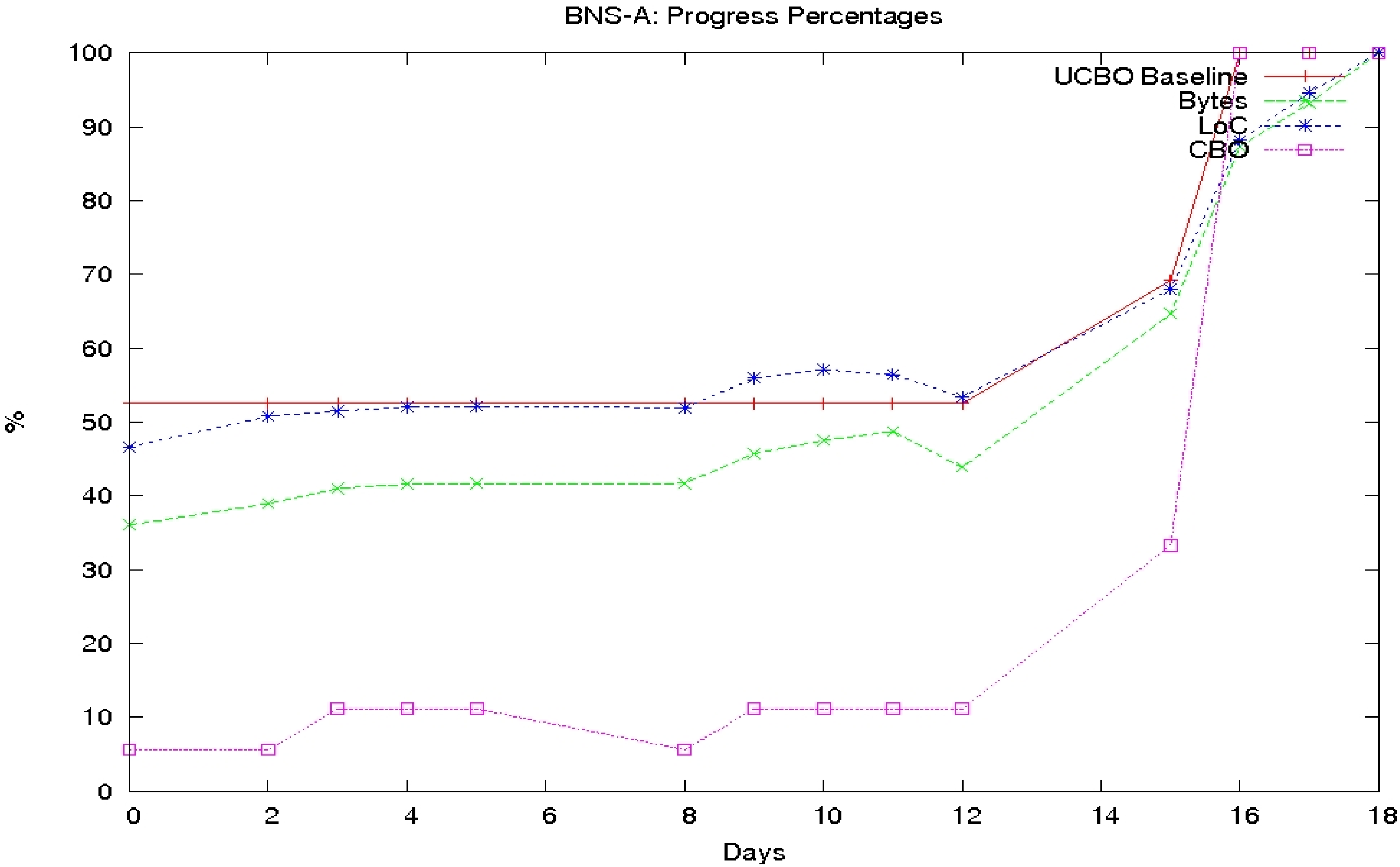

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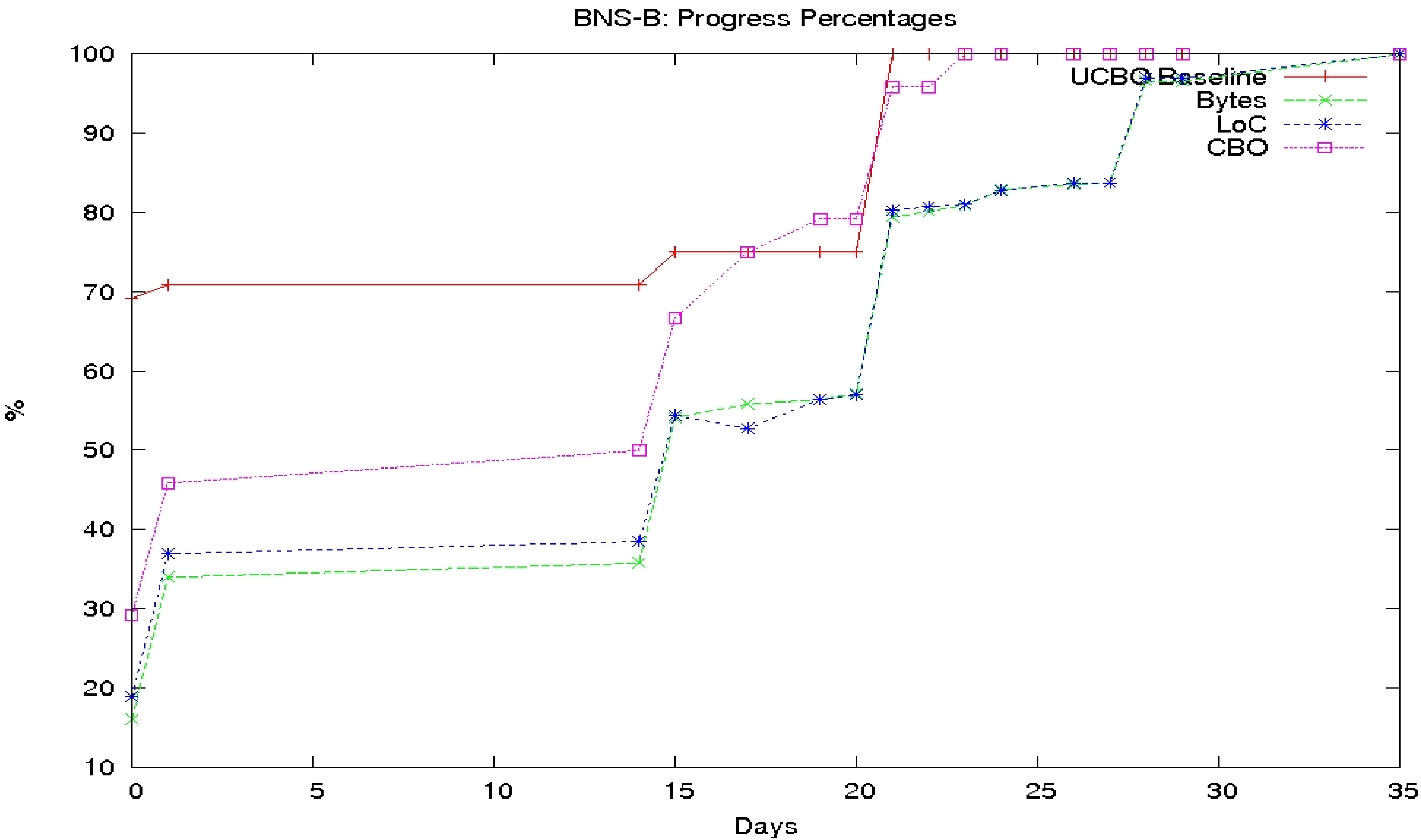

Conclusions and Future Work

- The proposed approach effectively helped to determine when the project is near completion (in terms of CBO measures).
- Some challenges need to be addressed: to avoid sudden picks and falls of the resultant progress pattern.
- Although we cannot tell precisely to which extent our methodology is useful, we think can help mainly at monitoring and reporting progress of software implementation of first releases.