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POLYTECHNIQUE
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Ptidej
Pattern Trace Identification, Detection, and Enhancement in Java

Soccerlab
SOftware Cost-effective Change and Evolution Research Lab

OdMoMS: Multi-Objective Miniaturization of Software

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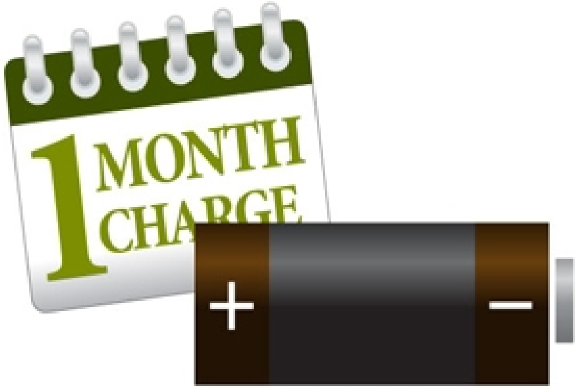
Motivation

PORT
HAND HELD DEVICES
How?
SMS
NEWS

Resources vs. Feature vs. Customers

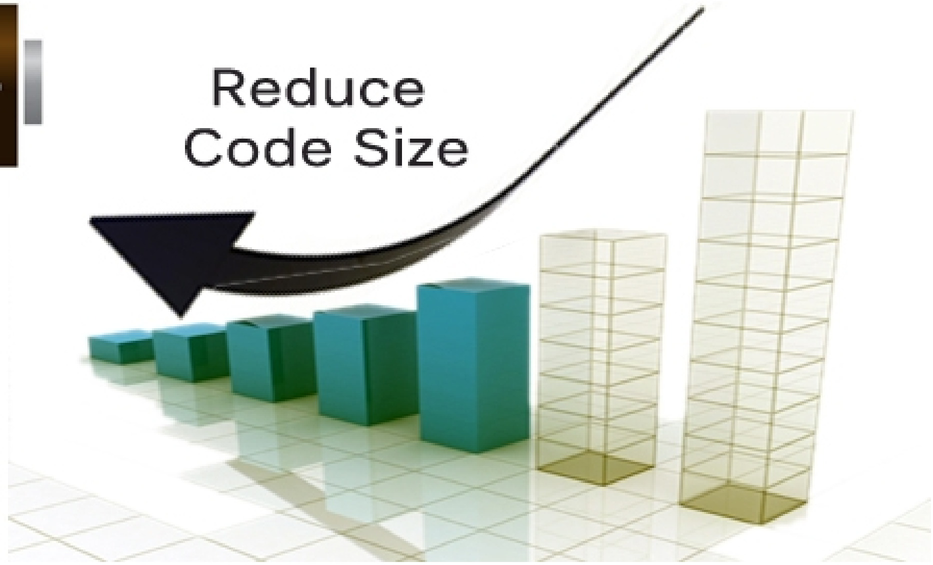
Our Goal

Better Performance

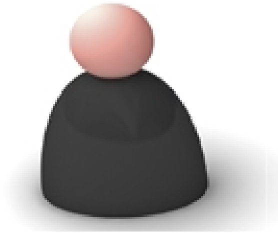


Maximize Customers' Satisfaction

Reduce Code Size



Different Customers – Different Features



Customer Relative Weight

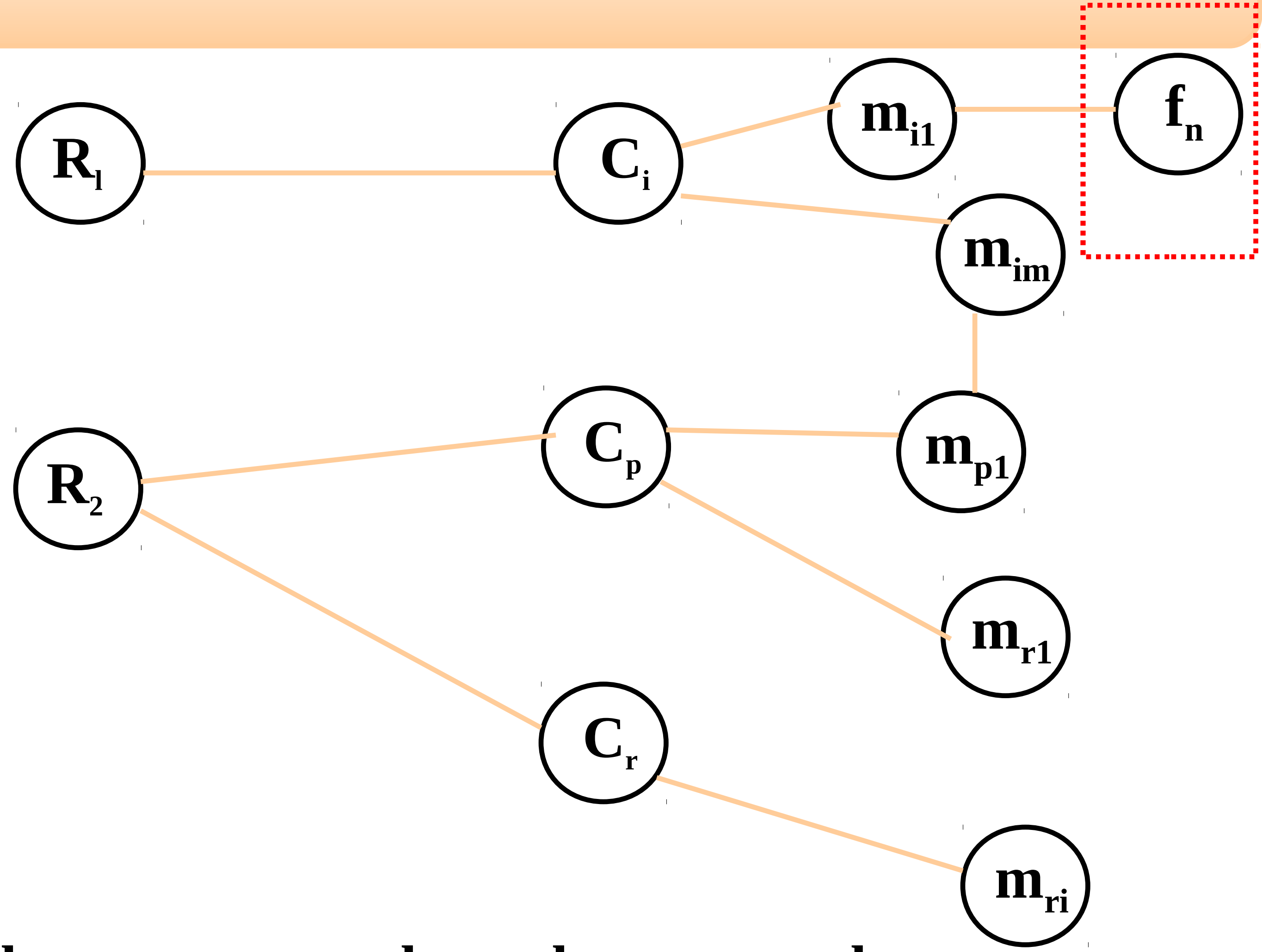
Overall

- What do customer want?
  - What do we already have ?
  - PREREQUIR + ReORe.
- How can we make customers happy?
  - Static vs. dynamic information
  - Size vs. features vs. happy customers vs. CPU consumption
- Miniaturization problem.
- Case Study.
- Conclusion.

PREREQIR in a Nutshell

- We need pre-requirement documents:
  - What the competitors' systems do?
  - What our customers want?
- We obtain and vet a list of requirements from diverse stakeholders.
- We structure requirements by mapping them into a representation suitable for grouping via pattern-recognition and similarity-based clustering.

Static Traceability Map



The system may depend on external components e.g., an LDAP server

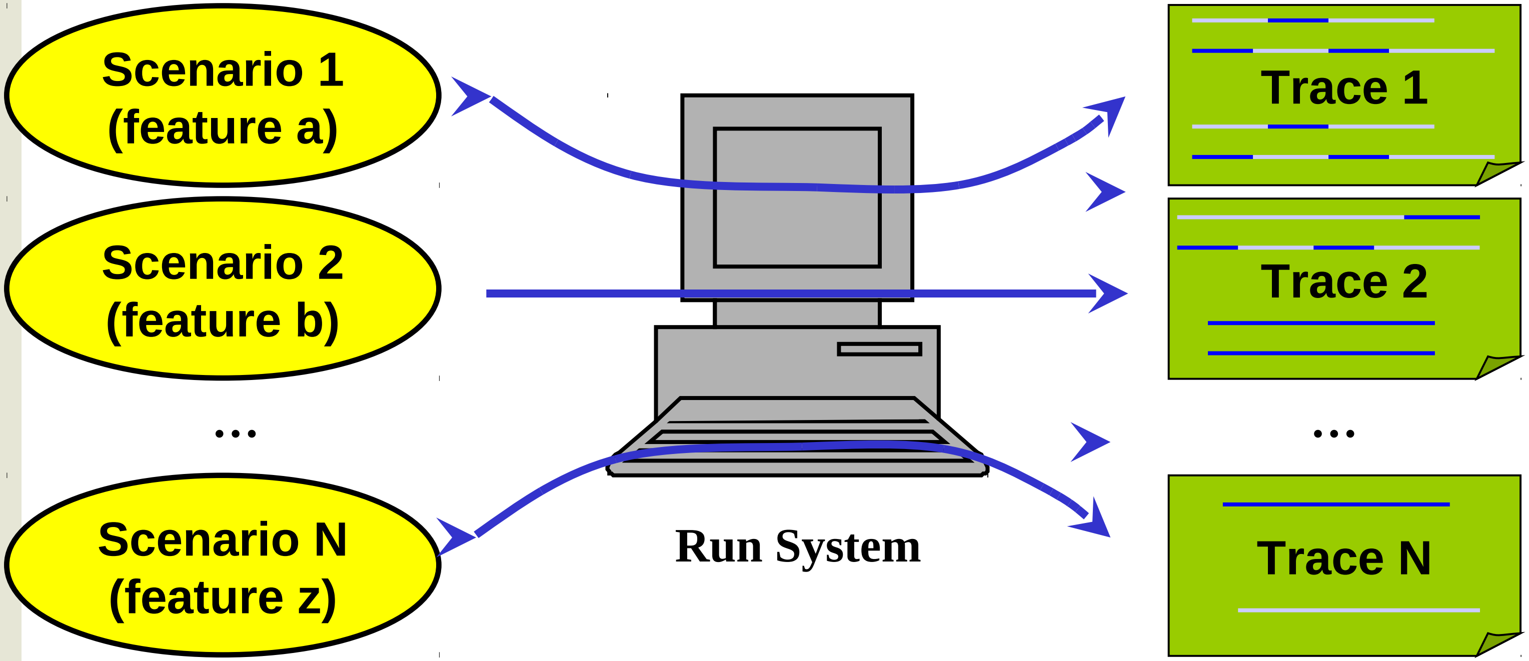
Features to Size

- Traceability relations are tagged with:
  - Size information.
  - IDs of customers requiring the given feature.
- Features are divided into:
  - Compulsory.
  - Cherry on the pie.
- Selected features must lead to a compilable system:
  - Extra code may be needed just to make sure that the system compiles and runs.

Features to CPU Consumption

- Assumption: CPU cycles/consumption is related to energy consumption:
  - The higher the CPU consumption, the lower the battery life.
- Binder’s JP2 profiling tool: comprehensive calling-context profiles:
  - Exact number of executed bytecodes for each calling context.
- Caveat: modern hardware architecture prevent exact estimation based on bytecode counting
- Bytecode counting is a good approximation of run time algorithmic complexity.
  - The lower the number of executed bytecodes, the lower the CPU time, the lower the battery consumption.

Requirements to Features



Dynamic Information

- Call tree:
  - Integrate call tree information for each executed feature with static traceability relations to count executed bytecodes.
- Evaluate CPU consumption at method level: accumulate into call tree top nodes the counts of lower nodes
  - Top nodes thus stores sub-tree bytecode counts.
  - Top nodes account for all executed bytecodes, including JARs and utility methods.
- Caveat:
  - Some feature may not be completely implemented.
  - Some feature may not be executed due to missing components.

Miniaturization Problem

- We would like to:
  - Minimize size and CPU consumption.
  - Maximize customer satisfaction.
- Constraints may be imposed on the search space
  - Max available memory, max CPU power, customers that must be satisfied.
- Generate a Pareto surface:
  - Project Pareto surface onto a Pareto front.
- Final decision to the manager.

Miniaturization Problem (cont’d)

$C = \{c_1 \ldots c_L\}$ L customers;

Each customer has "value" $0 \le \mathrm{v} \le \mathrm{V}_{\max}$ assigned;

A set of ComF compulsory features;

OF $= \{F_1 \ldots F_L\}$ customer desired optional features;

Each $\mathrm{F_i} = \left\{ f_{i1} \ldots f_{iN_i} \right\}$ list customer i desired features;

A miniaturized program implements $\mathrm{F}' \subseteq$ OF features;

We have a set of implementation units IU $= \{iu_1 \ldots iu_M\}$;

There are properties $\mathrm{P} \subset \mathrm{R}^{\mathrm{K}}$ that must meet a set of constraints HC $= \{hc_1 \ldots hc_k\}$ where hc_j is an interval

Miniaturization Problem (cont'd)

- Traceability creates a function Impl that given a feature assigns implementation units.
- Each implementation unit has assigned properties values, e.g., each method has assigned a size and a CPU consumption.
- The Customer Satisfaction Ratio (CSR) is defined as:

$$CSR(F') = \frac{\sum_{i=1}^{L} \frac{|F_i \cap F'|}{|F_i|} \times \frac{v_i}{V_{\max}}}{L}$$

Miniaturization Problem (cont’d)

- Maximize CSR(F’) means minimize –CSR(F’)

- For a given set of features F’, the implementation units and the overall properties are:

$$IU^{'} = \mathrm{Impl}\left(\mathrm{F}' \cup \mathrm{ComF}\right)$$

$$P' = \mathrm{Prop}\left(\mathrm{Impl}\left(\mathrm{F}' \cup \mathrm{ComF}\right)\right)$$

- We assume that properties are additive: size (CPU consumption) of two units is the sum of units sizes (CPU consumptions).

Miniaturization Problem (cont’d)

$$\min_{F' \in 2^{OF}} \left\{ -CSR(F'), \mathrm{Prop}\left[\mathrm{Impl}\left(\mathrm{F'} \cup \mathrm{ComF}\right)\right] \right\}$$

$$\text{such that :}$$

$$\forall\, \mathrm{p_i} \mid \left(p_1 \ldots p_i \ldots p_K \right) = \mathrm{Prop}\left[\mathrm{Impl}\left(\mathrm{F'} \cup \mathrm{ComF}\right)\right] : \mathrm{p_i} \in hc_i$$

Notice that $\mathrm{Prop}\left(\mathrm{Impl}\left(\mathrm{F}' \cup \mathrm{ComF}\right)\right)$

is actually an array of sizes and CPU consumptions. Thus, a solution is a surface:

CSR = FUNC(size, CPU consumption)

Case Studies

- 350 questionnaires, 73 completed surveys
- Pooka V2.0 e-mail client:
  - 208 classes.
  - 20,868 methods.
  - 245 KLOCs.
  - 599 pre-requirements.
  - 30 traced features.
  - Code size 5.39 MB.
- SIP V1.0 audio/video internet phone:
  - 1,771 classes.
  - 31,302 methods.
  - 486 KLOCs.
  - 639 pre-requirements.
  - 36 traced features.
  - Code size 27.3 MB.

NSGA-II Parameters

- We used JMETAL:
  - Mutation probability 4%.
  - Crossover 90%.
  - Evaluation number 25,000.

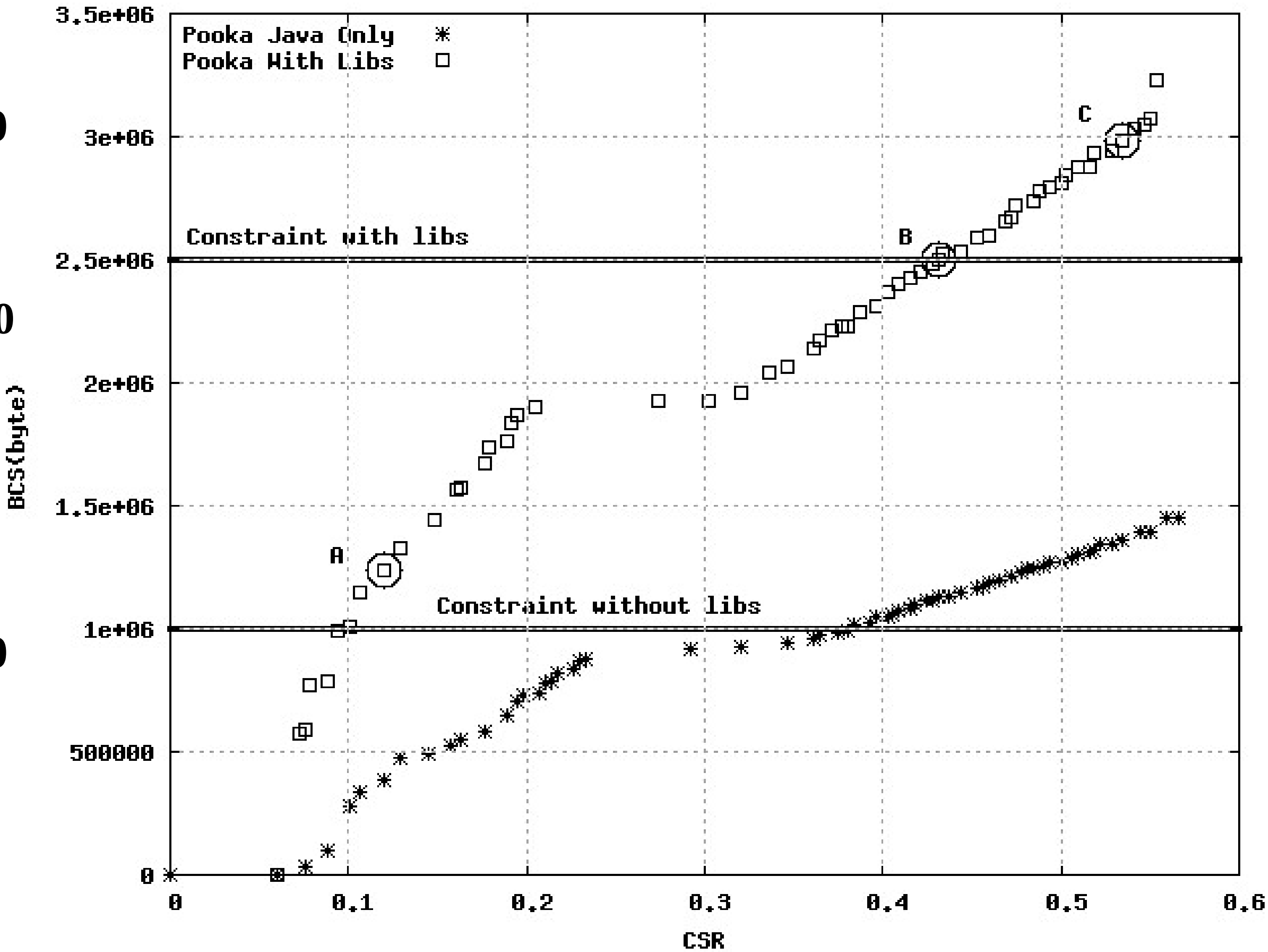
- High iteration number to ensure that we did not miss good solutions.

Pooka Projection CSR vs. Size

A: CSR = 0.21
Features: 15/30

B: CSR = 0.5
Features: 19/30

C: CSR = 0.56
Features: 23/30

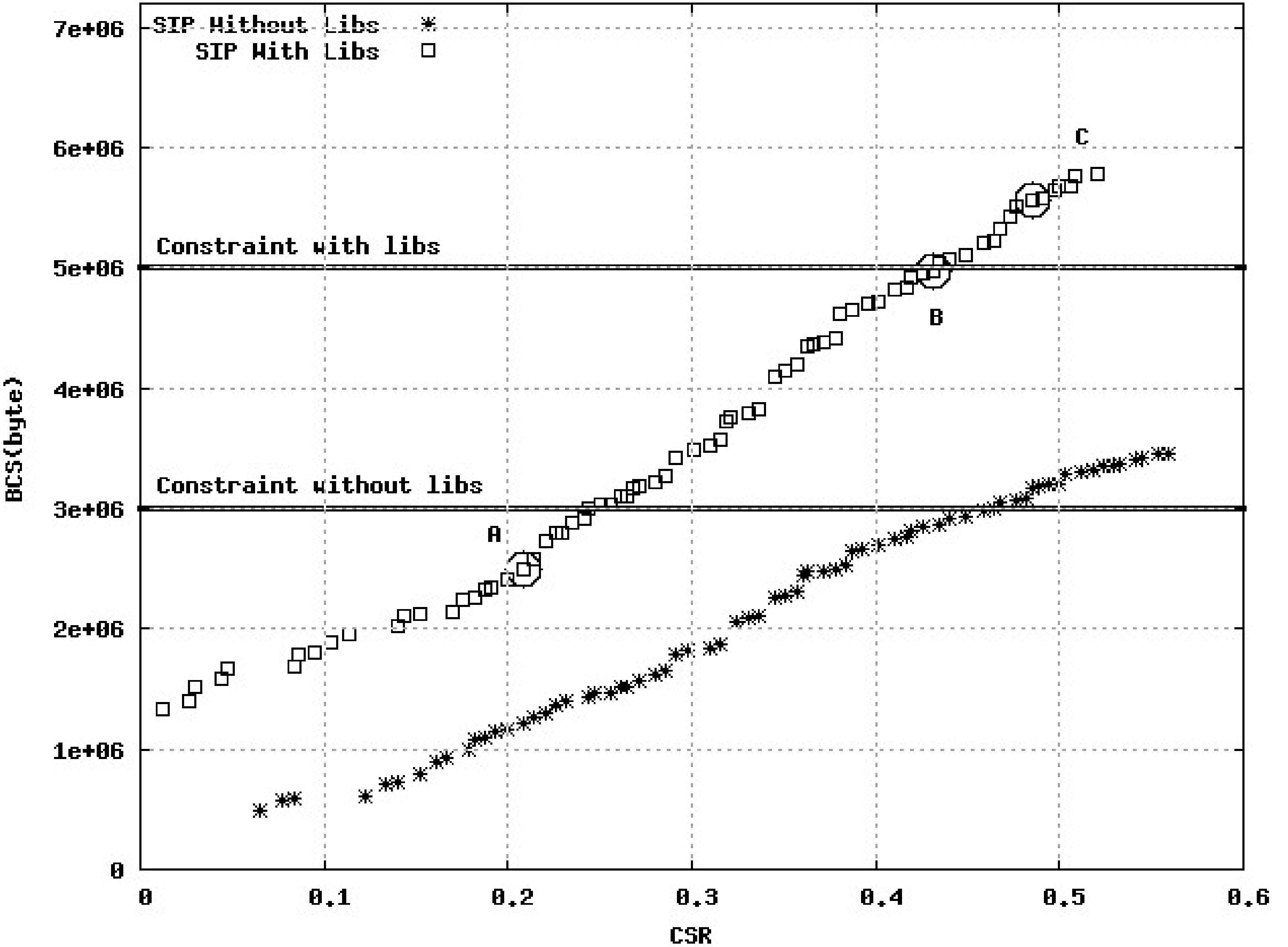


SIP Projection CSR vs. Size

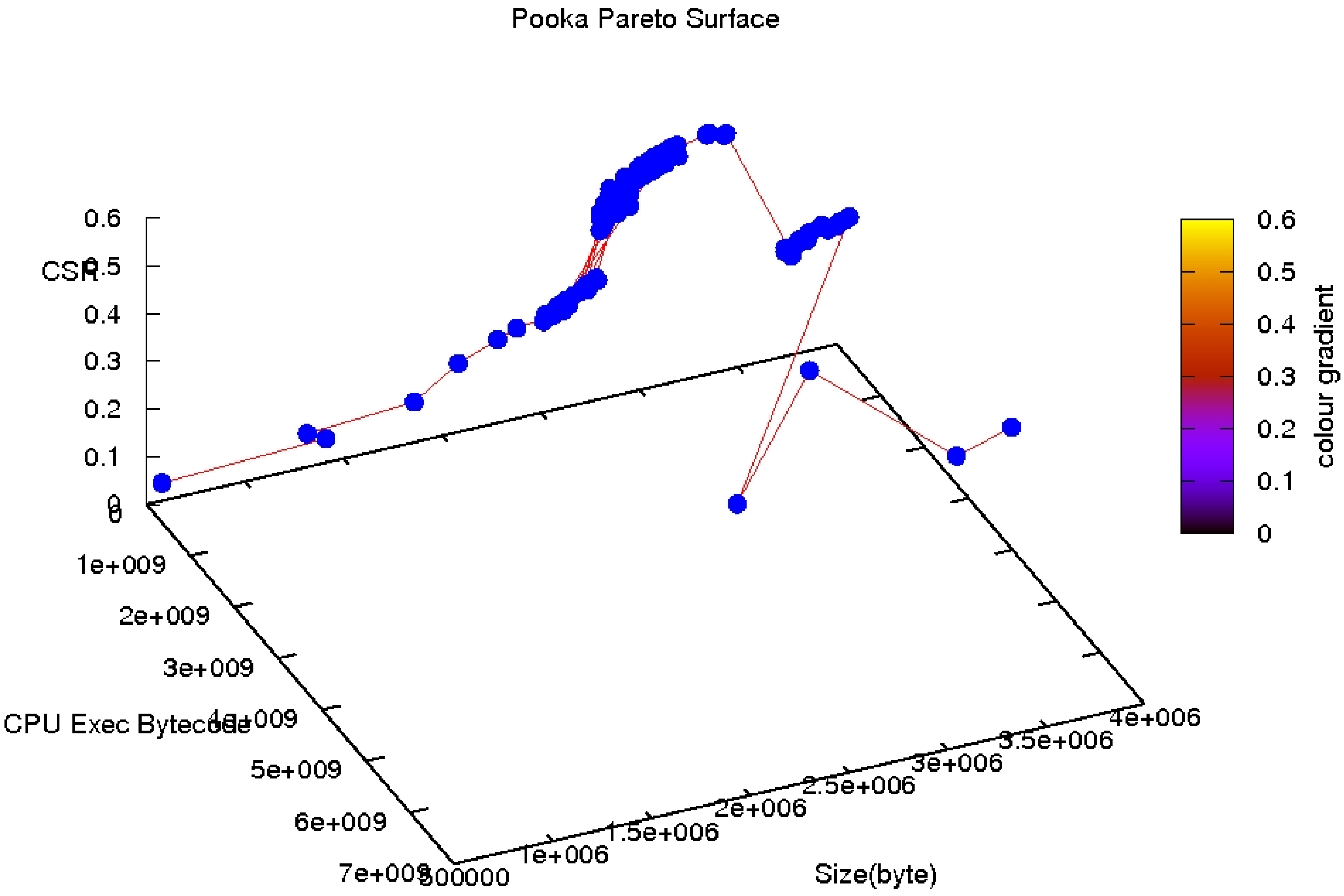
A: CSR = 0.20
Features: 10/36

B: CSR = 0.49
Features: 23/36

C: CSR = 0.56
Features: 31/36



Pooka Surface



Lessons Learned

- The miniaturization process is feasible but there are challenges:
  - Traceability recovery and accuracy of traced links.
  - Collecting dynamic information is difficult:
    - Missing or not 100% implemented features.
    - CPU consumption difficult to run:
      - We are still completing SIP.

- Some system (SIP) may exhibit tangled dependencies and there may be no sweet spot.

Conclusion

- The porting problem was modeled as a multi-objective minimization problem.

- Equations can accommodate a wide range of properties.

- The process can be automated thus saving considerable manual effort in selecting features to be ported:
  - Yet not in validating traceability links if links do not exist.

Questions