RUTGERS

THE STATE UNIVERSITY OF NEW JERSEY

CS 516 Compilers and Programming Languages II

Redundancy-2

Annoucements

Project #2 will be posted over the weekend (Sunday night)

Tuesday (next) lecture:

- →Shaleen will talk about polyhedral optimizations
- →Phillip will present work on intermittent energy optimizations

Papers are posted under sakai/resources

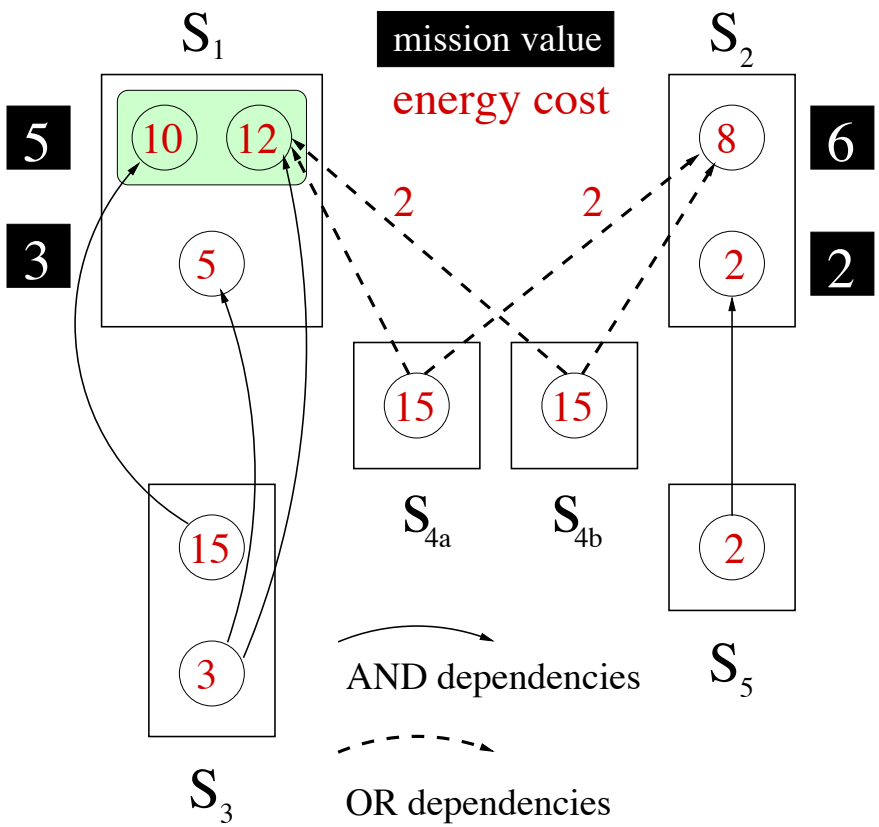
Annoucements (cont.)

- SGS graduate students enrolled in graduate level classes (16:xxx:500 and above) or in undergraduate courses that are approved parts of their graduate curriculum have the option to switch their grading modality from A, B, C, F letter grades to P/NC for any Spring 2020 class through May 22, 2020. The "P" grade replaces the A, B, C letter grades. The "NC" grade replaces the F letter grade.
- P/NC grades will be allowed for the Spring 2020 semester only.
- "P" grades will count towards the credits required for the degree, but they will not enter into GPA calculation.

The information listed above only partially covers issues related to P/NC, or dropping a course. Please reach out to your advisor if you have any questions or concerns.

Redundant Services Dependence Graph (RSDG)

The RSDG is a dually weighted, directed graph. The weights are cost (**C** - resource consumption) and mission value (**Q** - quality). For simplicity, we assume that all cost/quality models are linear.



Node and edge are associated with a cost C (here energy). No label means 0 cost.

Node mission values and execution budgets are provided by the user. Mission values may only be given to user-critical services (nodes).

Basic structure of 0-1 problem:

$$\underset{s}{\text{maximize}} \quad \sum_i \sum_j s_i^j * Q_i^j$$

$$\text{subject to} \quad \sum_{j=1}^{n} s_i^j <= 1$$

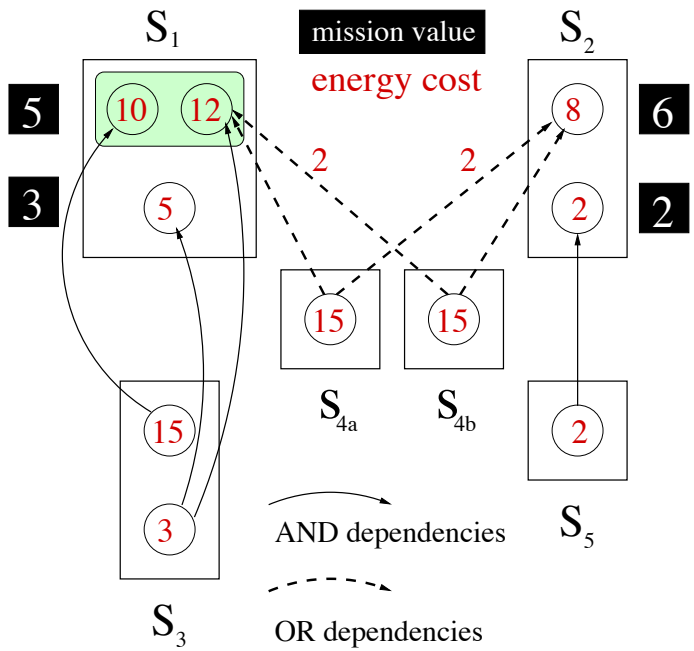
$$\sum_i \sum_j C_i^j < Budget$$

$$\textbf{foreach } Edge_{AND}(so \longrightarrow si), si - so <= 0$$

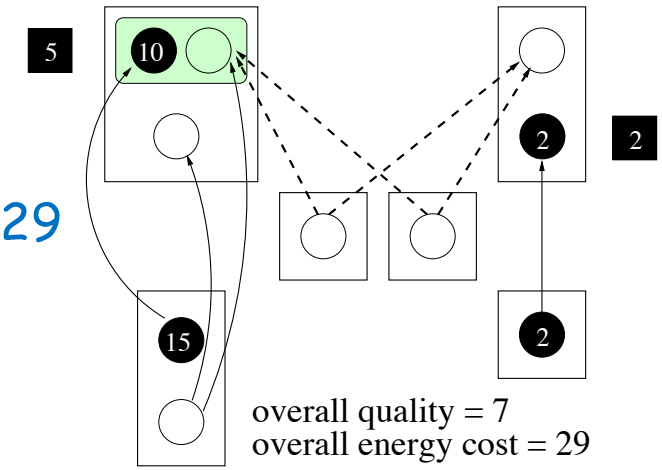
$$\textbf{foreach } Edge_{OR}(so_1, so_2, \ldots so_n \longrightarrow si), si - \sum_i so_i <= 0$$

Redundant Services Dependence Graph (RSDG)

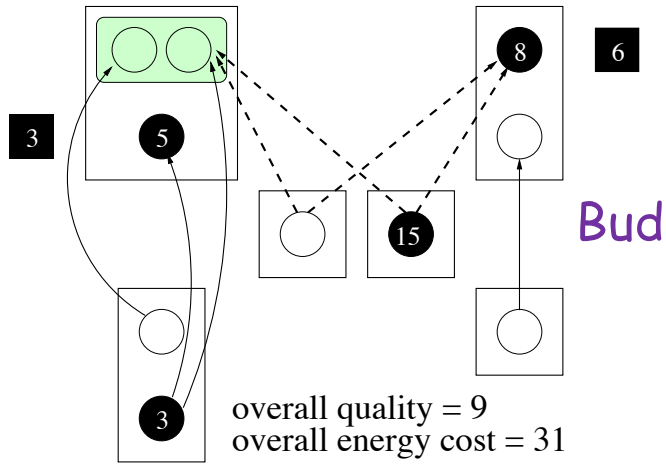
Example solutions for different provided resource budgets.



Budget = 29



Configuration = $\{S^{1A}_1, S^1_3, S^2_2, S^1_5\}$



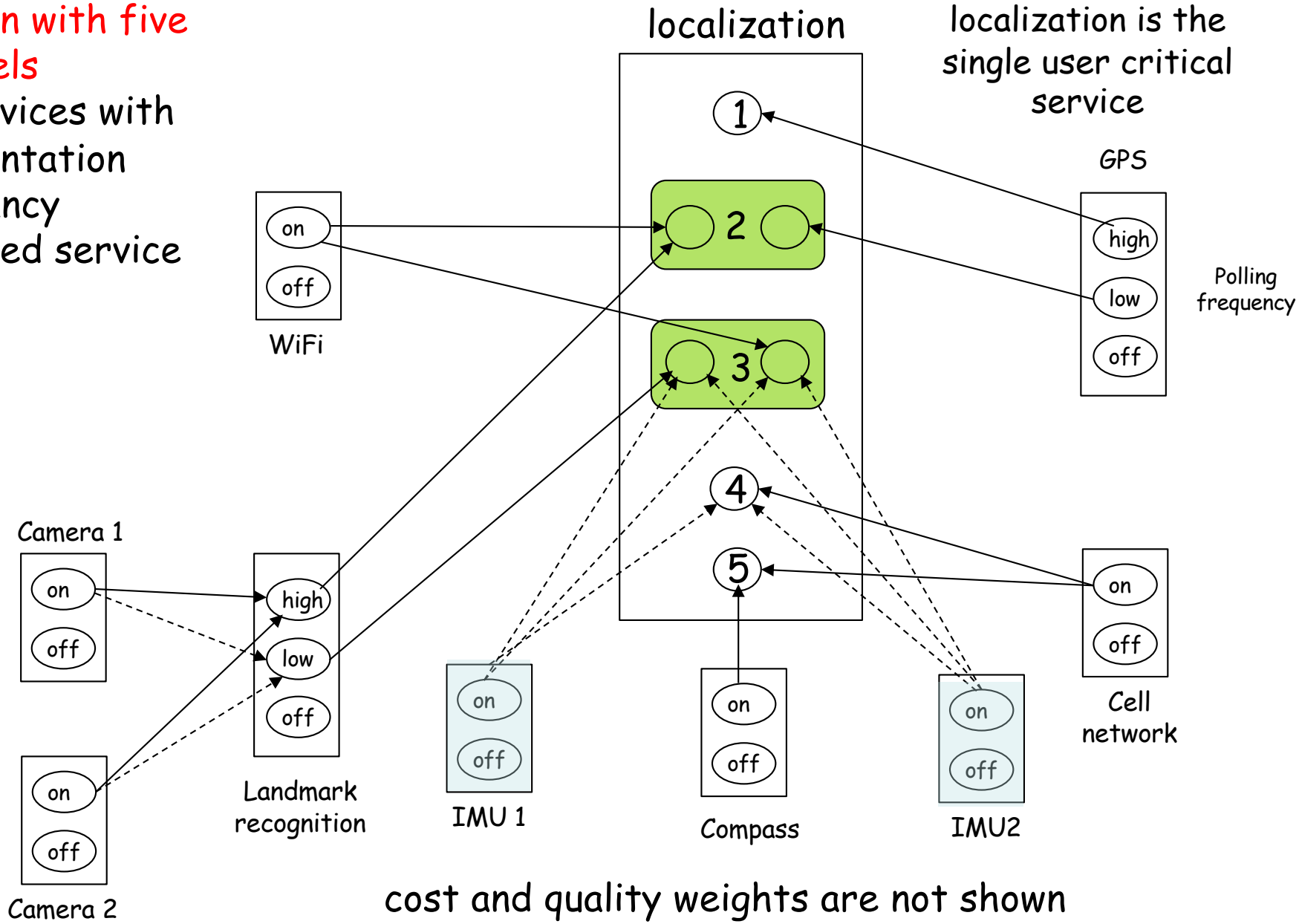
Budget = 31

Configuration = $\{S^2_1, S^2_3, S^1_2, S^1_{4B}\}$

Sample RSDG – localization service

Localization with five quality levels

- Two services with implementation redundancy
- one cloned service



cost and quality weights are not shown

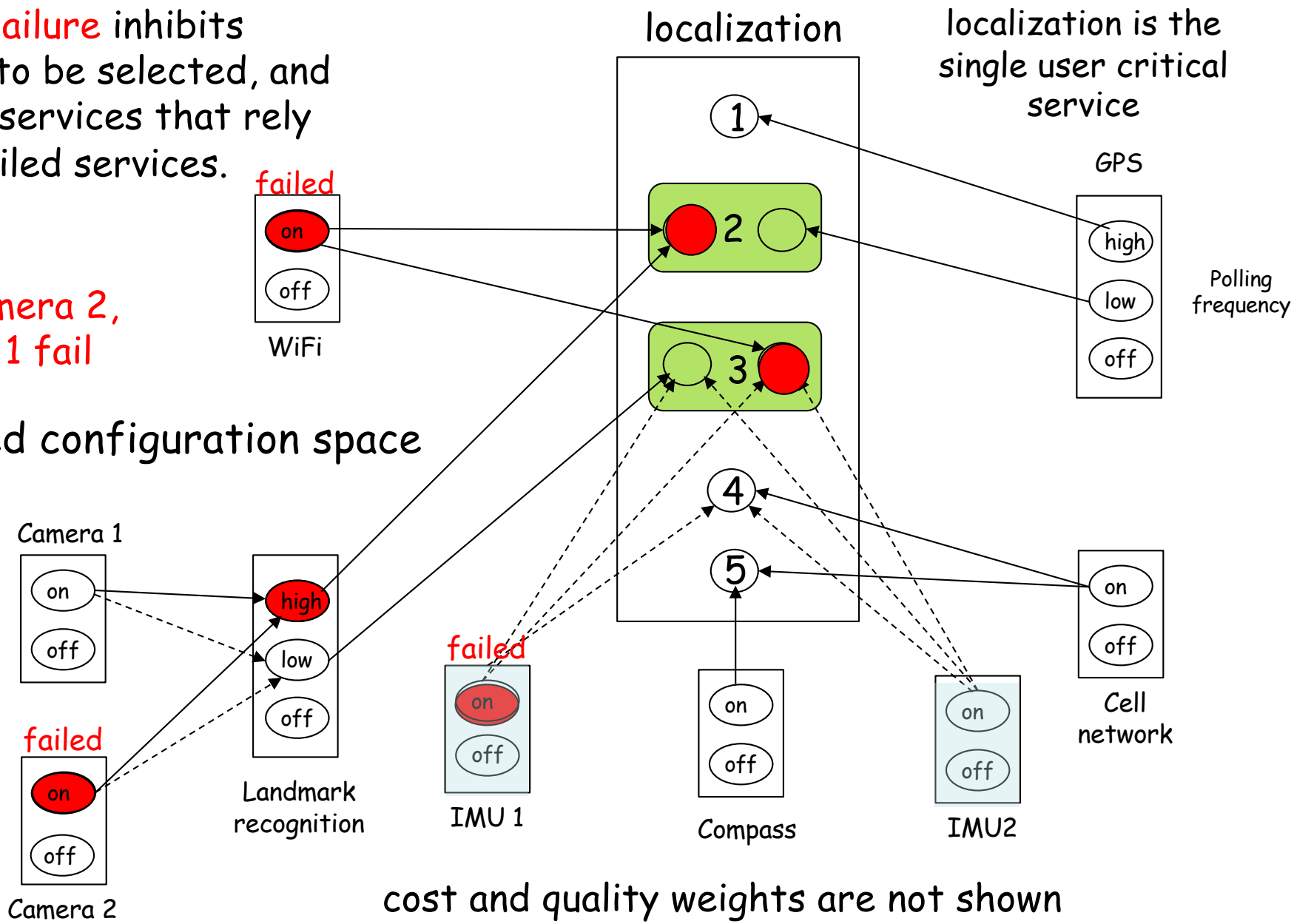
implementation replication / cloning

Sample RSDG – localization service

Service failure inhibits services to be selected, and all other services that rely on the failed services.

Example:
WiFi, Camera 2, and IMU 1 fail

⇒ limited configuration space



cost and quality weights are not shown

implementation replication / cloning

Sample RSDG – localization service

Possible metrics that describe the redundancy/robustness of a system

(1) Given a set of failed services FS (single and multiple failed services):

- Reduction in configuration space size due to FS
- Reduction in configuration selections of user critical services due to FS
- Reduction in available approximation levels for user critical services

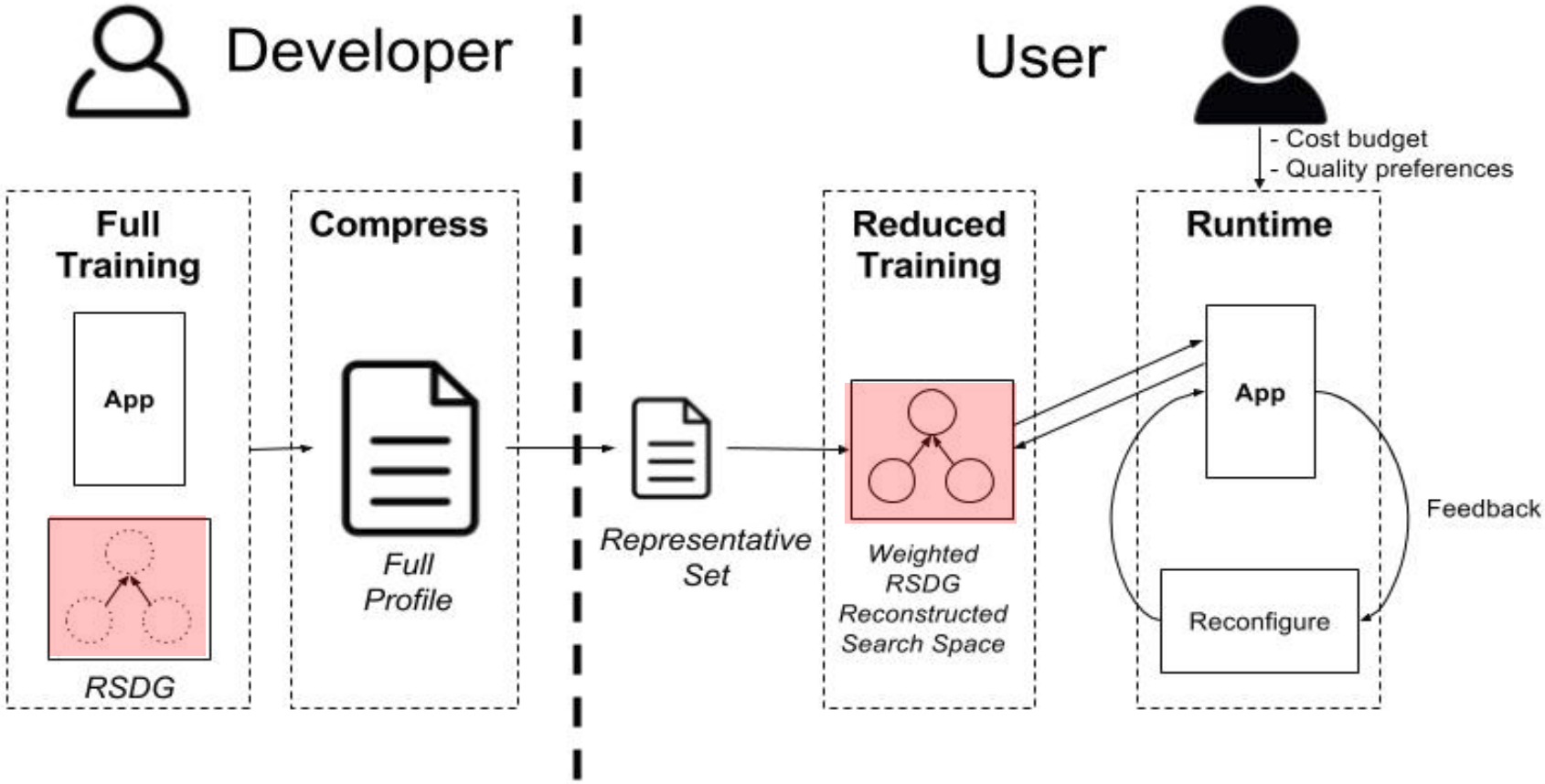
(2) Sensitivity analysis to budget/resource reductions: Similar metrics can be used to assess the impact of budget reductions

(3) Impact of failures / limited budgets on quality of optimal configuration. Enable "what if" experiments

⇒ Metrics can be used to assess and guide the design of robust/redundant systems

Basic RAPIDS structure

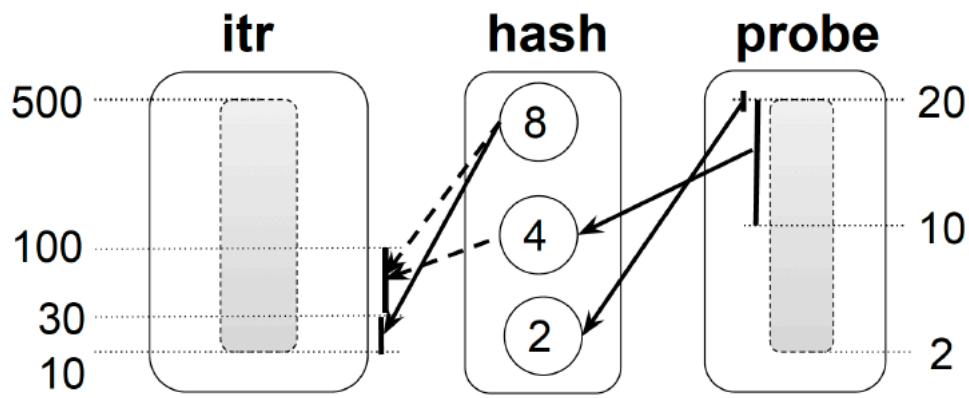
Possible use of RSDG in a development / execution environment



Basic RAPIDS structure

Possible use of RSDG in a development / execution environment

Developer



3 knobs/services: Labels are value settings, not cost or quality weights

Ferret from PARSEC benchmark suite (Princeton U.)

<Continuous Knobs>:
itr [10,500] INT; probe [2,20] INT;

<Discrete Knobs>:
hash {2,4,8} INT ;

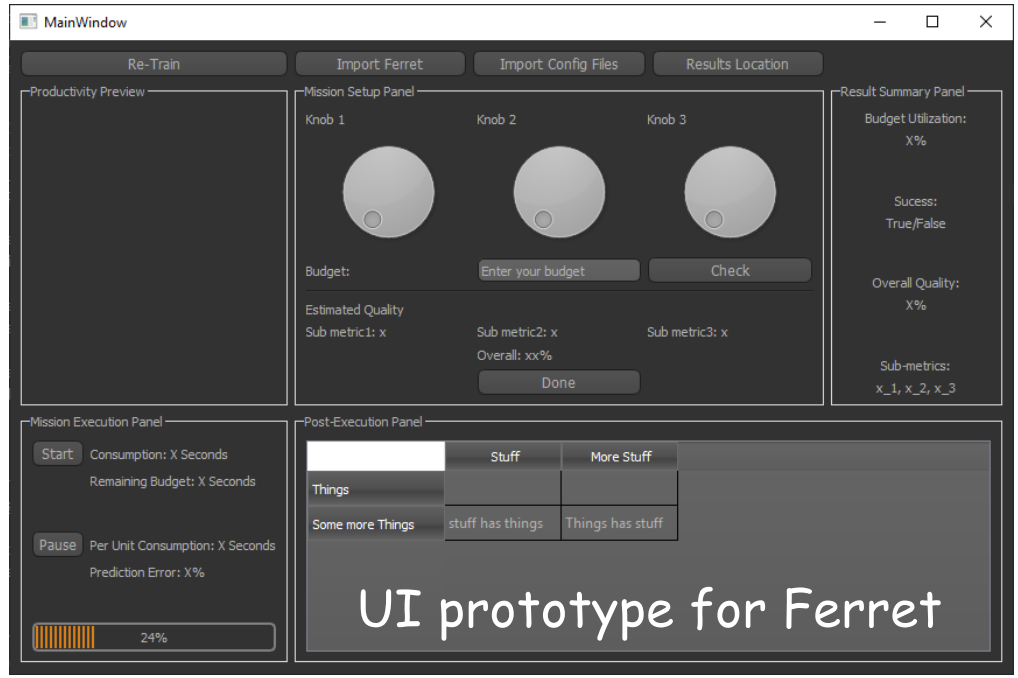
<Dependencies>:
AND: itr [10,30] ← hash {8} ; OR: itr [30,100] ← hash {4}, hash {8};
AND: hash {4} ← probe [10,20] AND: hash {2} ← probe [20,20]

<Sub-Metrics>:
Coverage, Ranking

Basic RAPIDS structure

User

Specifies quality preferences and resource budget (maximal execution time – soft deadline)

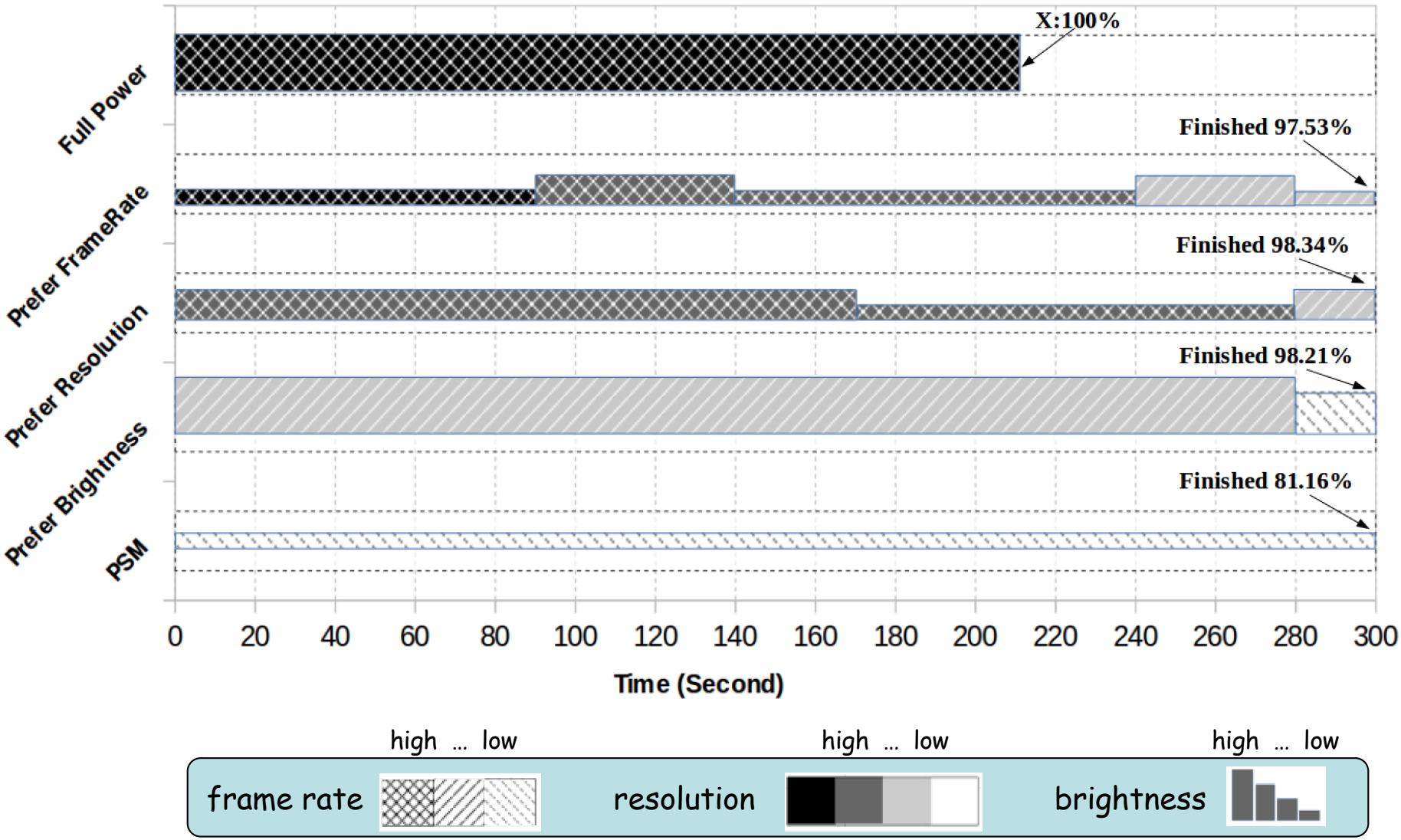


Framework Runtime

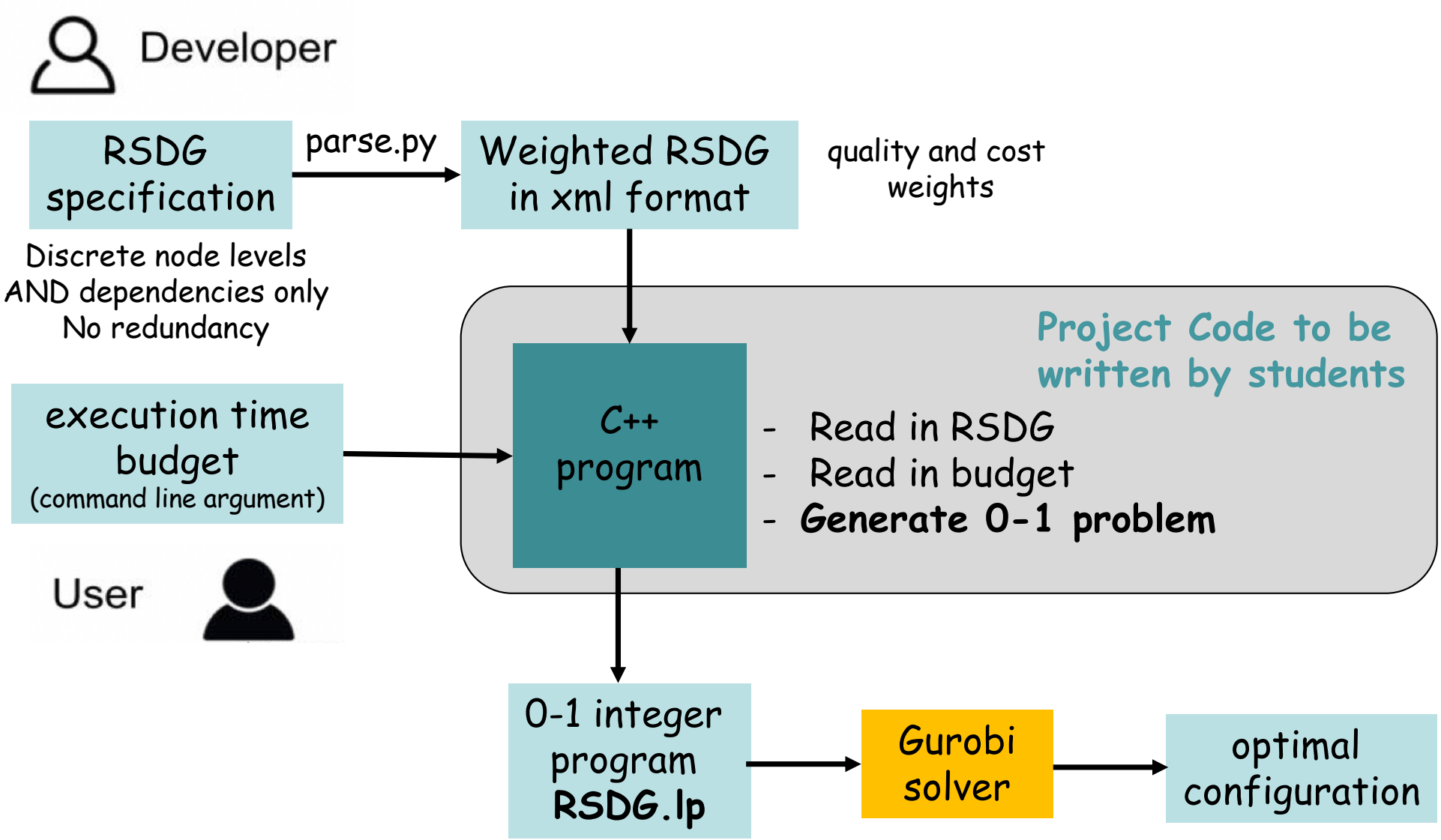
- Monitors application progress, resource consumption, failures
- Remapping solved as an integer programming problem (gurobi)
- Remapping triggered when
  + mismatch of predicted resource usage to actual observed usage beyond tolerance threshold. Possible reasons:
    - errors in prediction model
    - unforeseen change in execution/resource environment
  + system component failures
  + low resource utilization (observed in fixed time intervals)

Dynamic reconfiguration

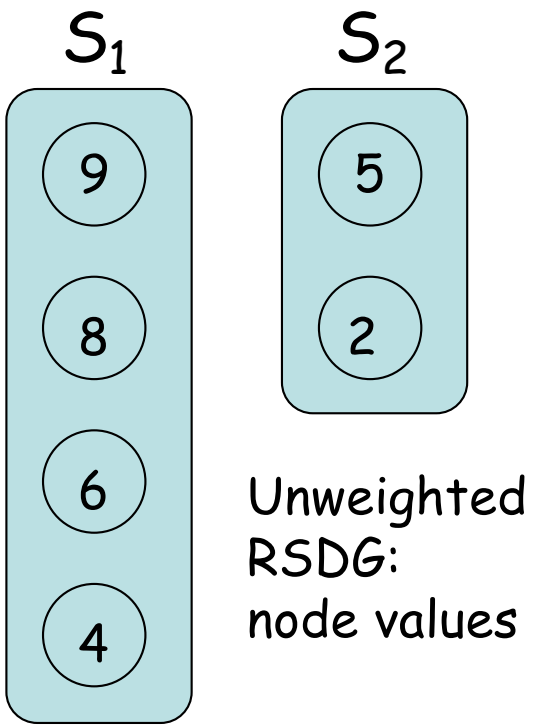
Sample video application execution with custom quality under a fixed budget



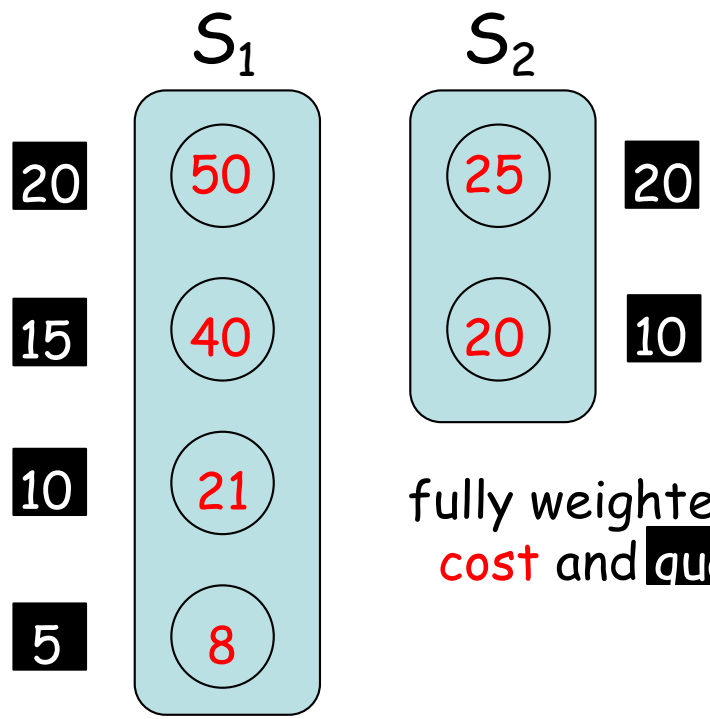
Project #2


Developer
RSDG specification
parse.py
Weighted RSDG in xml format
quality and cost weights
Discrete node levels
AND dependencies only
No redundancy
Project Code to be written by students
execution time budget
(command line argument)
C++ program
- Read in RSDG
- Read in budget
- Generate 0-1 problem
User
0-1 integer program RSDG.lp
Gurobi solver
optimal configuration

Project #2 - Sample RSDG



Unweighted RSDG: node values



fully weighted RSDG: cost and quality

RSDG.lp with budget=70

```
<Discrete Knobs>;
S1 [4, 6, 8, 9] INT;
S2[2, 5] INT;
```

```
Maximize
  20 S1.4 + 40 S1.3 + 10 S1.2 + 5 S1.1 +
  20 S2.2 + 10 S2.1
Subject To
  cost: 50 S1.4 + 40 S1.3 + 21 S1.2 + 8 S1.1 +
        25 S2.2 + 20 S2.1 <= 70
  S1.Select: S1.1 + S1.2 + S1.3 + S1.4 = 1
  S2.Select: S2.1 + S2.2 = 1
Binary
  S1.1 S1.2 S1.3 S1.4 S2.1 S2.2
End
```

⇒

Objective value = 35
S1.3 = 1
S2.2 = 1