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Assessing the Complexity of Upgrading Software Modules

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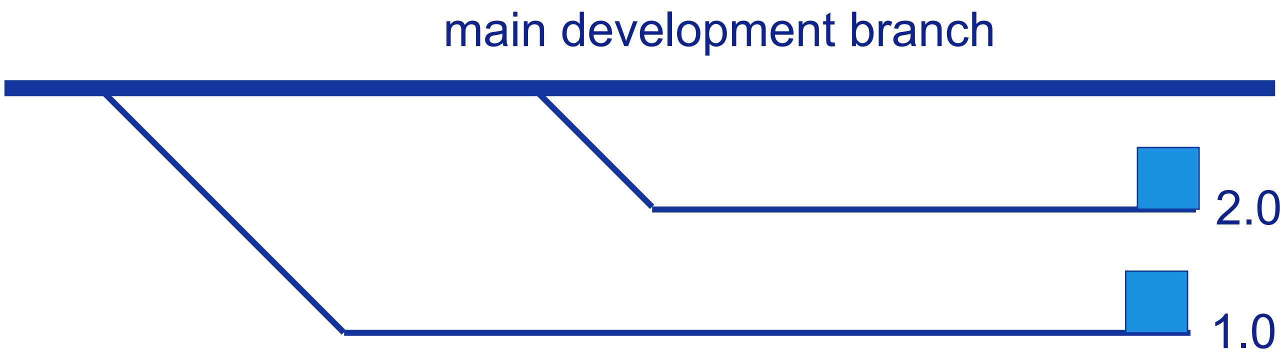
Motivation

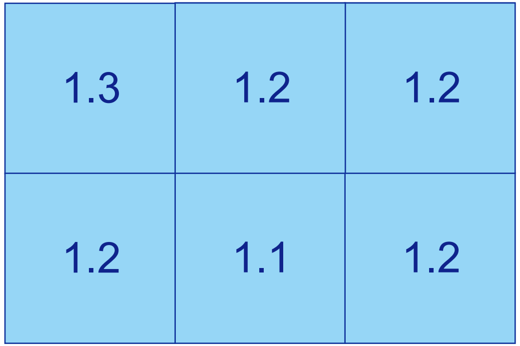
- Given a software system, continuously updated.

- **How to keep all branches in sync, including releases deployed at the customer?**

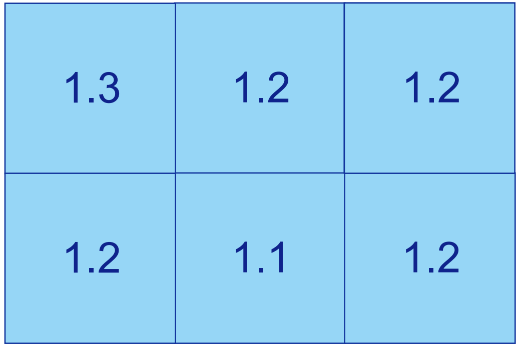
Approach 1: write patch for one release, apply elsewhere



Approach 2: use modules



Customer



Latest

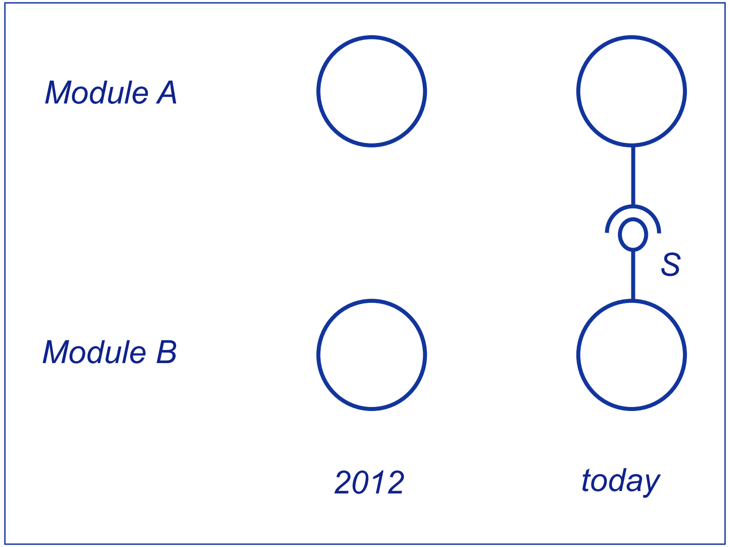
Motivation (2)

- When upgrading a module, dependencies should still be satisfied.

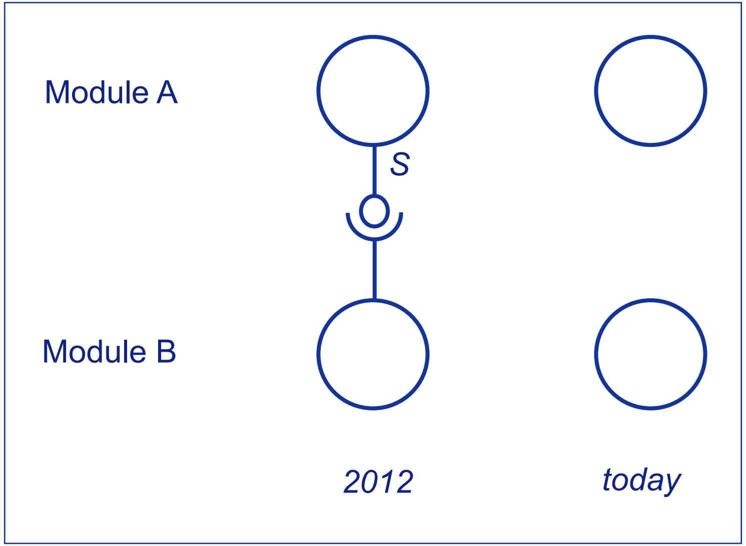
- Fewer dependencies => easier to upgrade.

- Given a software system, are modules sufficiently **independent** such that they can be **upgraded** easily?

Upgrade dependencies



New symbol added and used

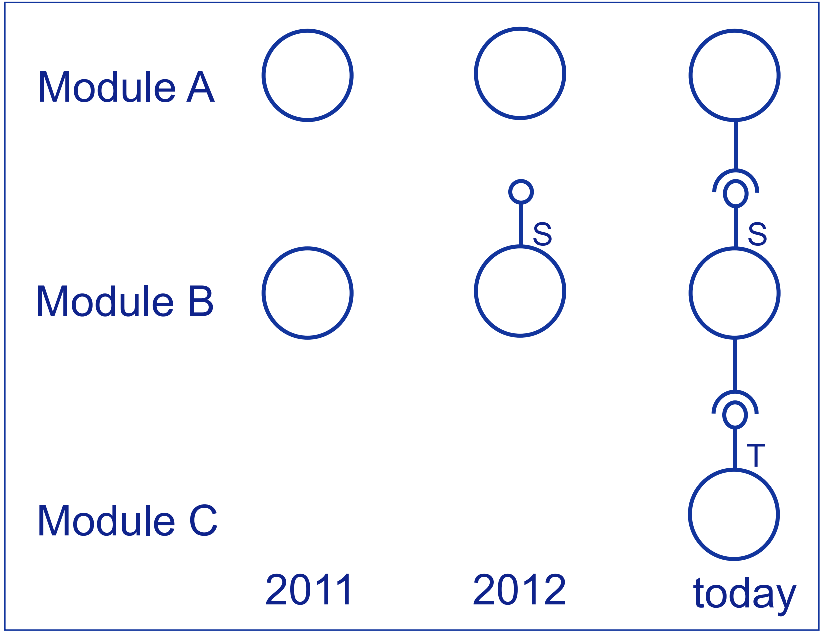


Symbol removed

Example of upgrade dependencies

Two alternatives for B providing symbol *S*.

Objective: Choose a **minimal** set of upgrade dependencies (limit impact).

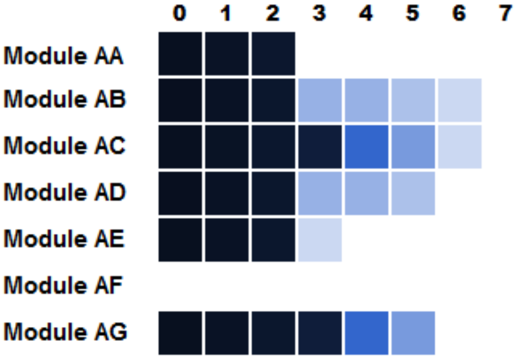


Approach outline

1. Gather syntactical interface usage data.

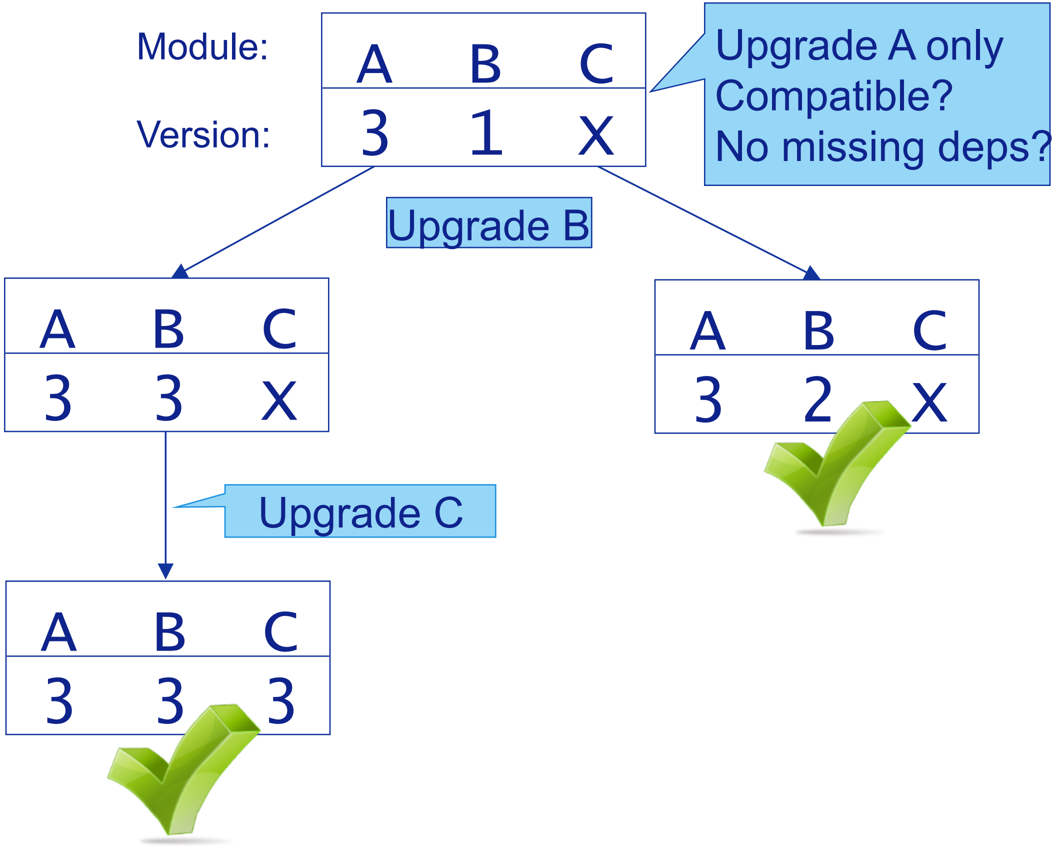
2. Compute for each module *m* the number of upgrade dependencies, upgrading *m* from version *i* to latest version.

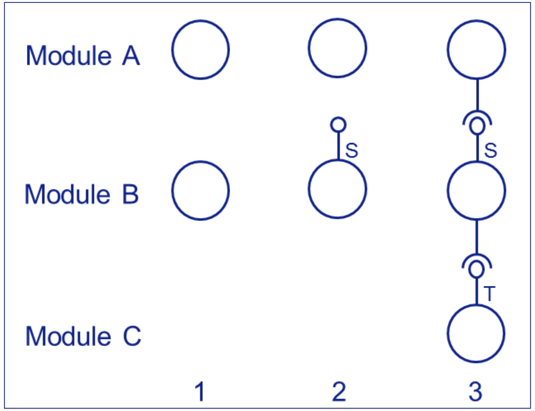
3. Visualize results:
   - Heat maps: high level overview
   - Dependency graphs: low level details of a particular upgrade



Find minimal number of upgrade dependencies

Goal: upgrade A from version 1 to 3

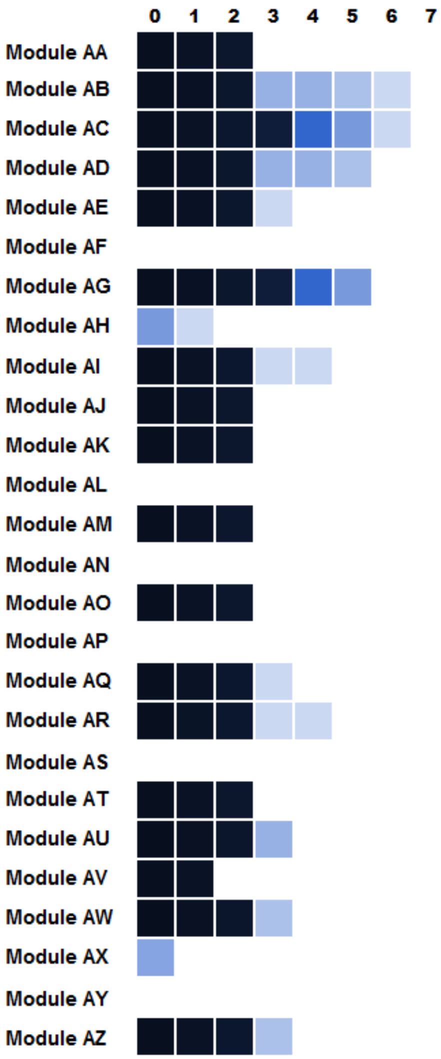




High level visualization: heat map

- Each cell indicates complexity for each module(rows) from an older version (column) to the latest version.

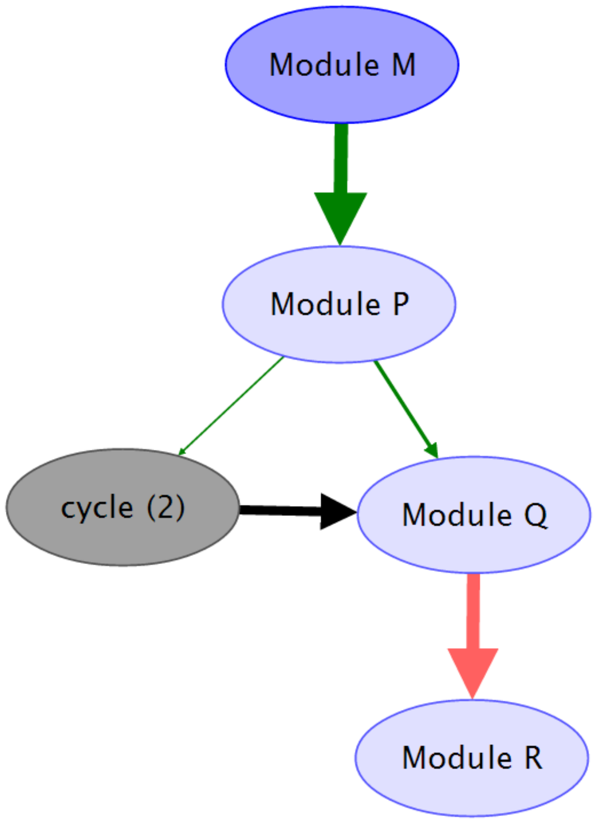
- Darker means more upgrade dependencies (hence, more complex).



Low level visualization: upgrade dependency graphs

- Dependency graphs provide more details about a particular upgrade

- **Vertices**: all modules involved with upgrade.
- **Edge** from module n_1 to n_2 iff
  there is an upgrade dependency from n_1 to n_2.
  - Green edge: upgrade dependency due to symbol addition(s).
  - Red edge: upgrade dependency due to symbol removal(s).
  - Black edge: green and red combined.
  - Thickness: number of symbols.



Case study performed at ASML Netherlands B.V.

- Manufacturer of chip-making equipment.
- Designs, develops and integrates systems to produce semiconductors.

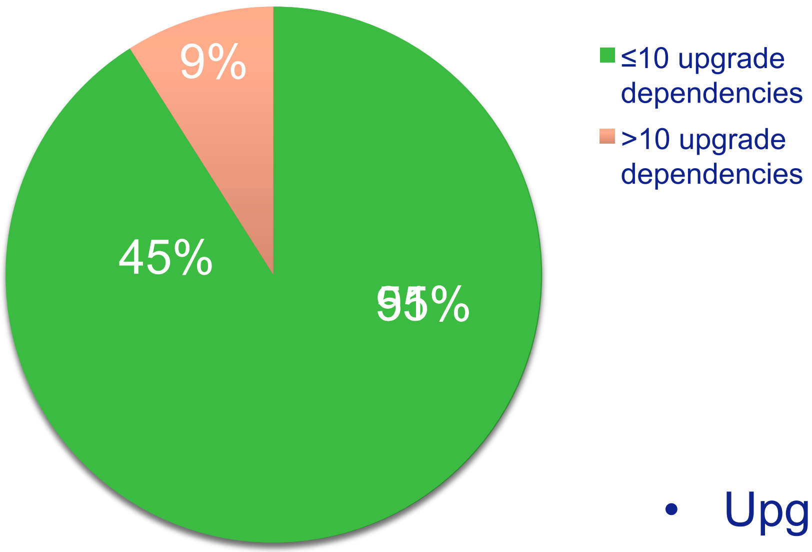
- 1000 software developers
- 40 MLOC
- 327 modules
- 7000 interfaces
- 9 versions of the software analyzed (between Oct. ’11 – Jul. ’12)

Result (1)

- Applied approach on software at ASML.

- 327 modules * 8 versions = **2616 upgrade scenarios**
- Processing time: **16 hours** for all scenarios
    - With limitations on search space.

Results (2)



- Upgrade dependencies due to removal of symbols
- What if we ignore the removal of symbols?

Conclusion

Synchronizing patches is time-consuming and error-prone.

Module-oriented patching: modules should be independent.

Determine upgrade dependencies for each module.

Case study: provided new insights in how modules are related and how to improve future upgrades.

ASML