Effective and Scalable Software Compatibility Testing

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CMSC 737 - Student Presentation

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Compatibility Testing

- Testing compatibility of components of a software
- Ensures that software will work (build/execute) with different version of the components
- Motivation:
  - Automated techniques unavailable
  - Large number of configurations make manual testing impossible

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Solution

- Rachet system software
- Evaluation
- Future work
- Discussion

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Rachet

1. Model configuration space
2. Determine coverage criteria
3. Produce test configuration and test plan
4. Execute test plan
   - Testing only that software builds

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Model Configuration Space

- Model components of a software and their relationships to other components
- Model versions of each component
- Model relationships between versions of components

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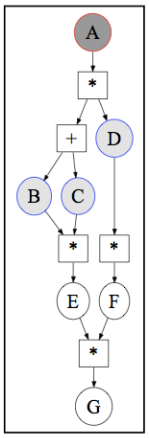
Model Configuration Space



Version Annotations

Component	Versions
A	A_1
B	B_1, B_2, B_3
C	C_1, C_2
D	D_1, D_2, D_3
E	E_1, E_2, E_3, E_4
F	F_1, F_2, F_3, F_4, F_5
G	G_1

Constraints

$(ver(C) = C_2) \rightarrow (ver(E) \geq E_3)$

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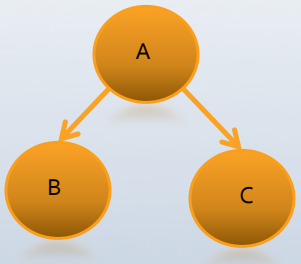
Determine Coverage Criteria

- Exhaustive (EX)
  - Generate configurations exhaustively
- Configurations for building A:
  - {B1,C1}
  - {B2,C1}
  - {B1,C2}
  - {B2,C2}



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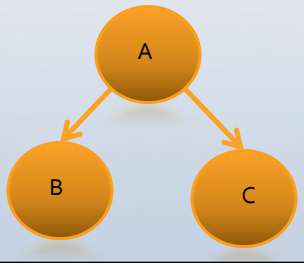
Determine Coverage Criteria

- Direct Depends: "A component directly depends on another component if there is path between the 2 components such that there isn't any other component on the path"
- Directly Depends (DD)
  - Cover all direct dependencies by at least one configuration
- Configurations for building A:
  - {B1,C1}
  - {B2,C2}



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Filter configurations

- Observation: " Multiple configurations might contain identical direct dependency sequence"
- Put configurations into a prefix tree (test plan)
- This reduces number of components to build
- For each configuration, nodes representing direct dependencies are added in order to the tree

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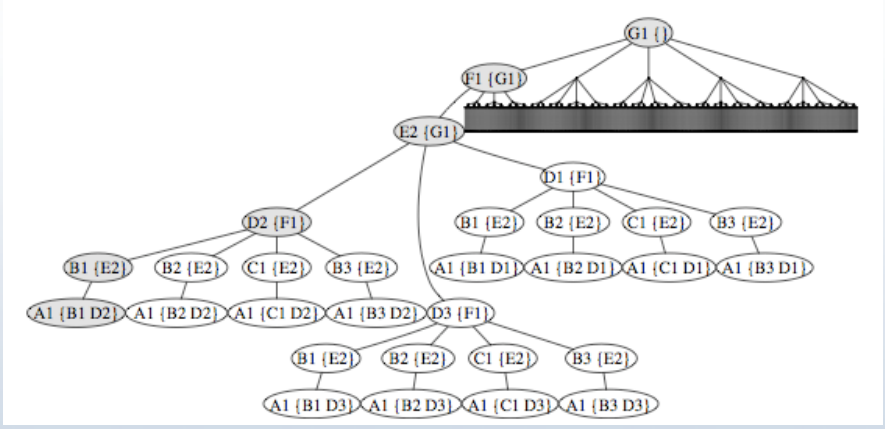
Prefix Tree (Test Plan)



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Rachet Test Execution Architecture

- Client/Server design
- Server controls the plan execution and distributes build tasks to clients
- Client connects to the server to ask for a single task and runs the given task
- Client has a cache which can be used to store dependencies
- VMWare is used to run the tests
- Server can send initial states to clients in the form VMWare files

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Strategies for running test plan

- Need to cover all nodes in the test plan
- Parallel Depth-First:
  - Utilizes locally cached tasks
  - Find next task by doing a depth first search
- Parallel Breadth-First:
  - Aims to maximize number of tasks being executed simultaneously
  - Secondarily maximize use of cache
- Hybrid approach
  - Designed to maximize parallelism and reusability of cache

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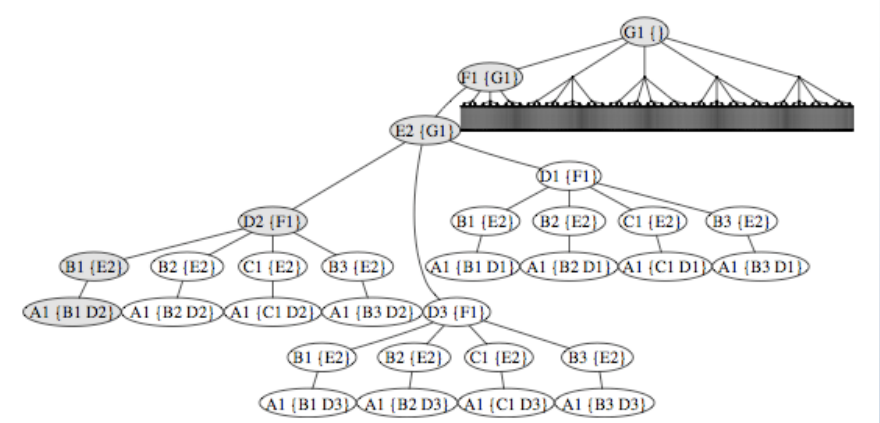
Test Plan



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Evaluation

- Research Questions:
  - How does exhaustive coverage compare to direct dependency coverage
  - Loss of effectiveness with direct dependency coverage
  - Which test execution strategy is better
- Test Rachet with 2 subject applications
  - InterComm
  - PETSc

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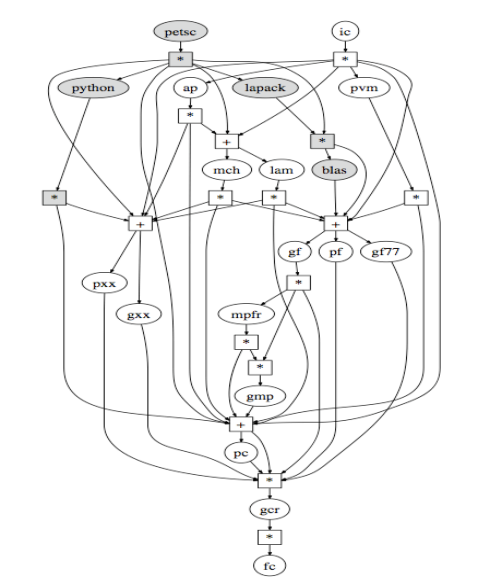
CDG for test subjects



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Component Versions

Comp.	Version	Description
petsc	2.2.0	PETSc, the SUT
ic	1.5	InterComm, the SUT
python	2.3.6, 2.5.1	Dynamic OOP language
blas	1.0	Basic linear algebra subprograms
lapack	2.0, 3.1.1	A library for linear algebra operations
ap	0.7.9	High-level array management library
pvm	3.2.6, 3.3.11, 3.4.5	Parallel data communication component
lam	6.5.9, 7.0.6, 7.1.3	A library for MPI (Message Passing Interface) standard
mch	1.2.7	A library for MPI
gf	4.0.3, 4.1.1	GNU Fortran 95 compiler
gf77	3.3.6, 3.4.6	GNU Fortran 77 compiler
pf	6.2	PGI Fortran compiler
gxx	3.3.6, 3.4.6, 4.0.3, 4.1.1	GNU C++ compiler
pxx	6.2	PGI C++ compiler
mpfr	2.2.0	A C library for multiple-precision floating-point number computations
gmp	4.2.1	A library for arbitrary precision arithmetic computation
pc	6.2	PGI C compiler
gcr	3.3.6, 3.4.6, 4.0.3, 4.1.1	GNU C compiler
fc	4.0	Fedora Core Linux operating system

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Test Plan Statistics

System	Type	Cfgs	Comp_{cfgs}	Comp_{plan}
InterComm	Ex-Cover	3552	39840	9919
InterComm	DD-Cover	158	1642	677
PETSc	Ex-Cover	1184	14336	3493
PETSc	DD-Cover	90	913	309

- For InterComm Ex-Plan (Total 9919):
  - Successful: 461
  - Failed: 687
- For InterComm DD-Plan (Total 677):
  - Successful: 275
- Large number of components could not be tested

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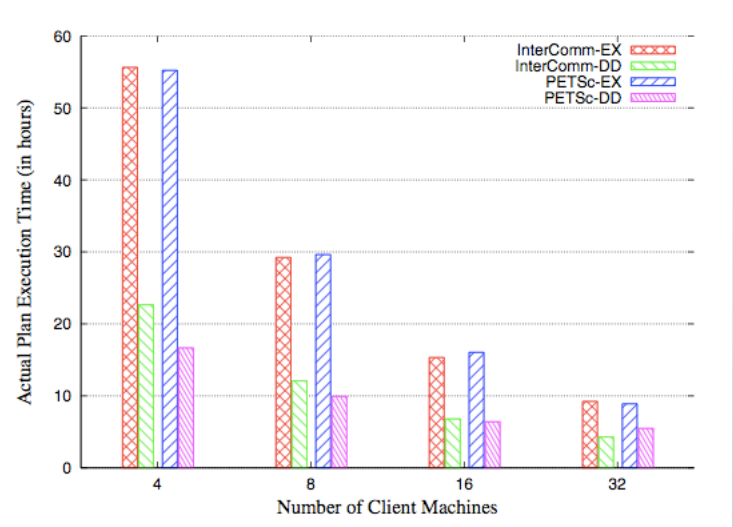
Results

- DD is 2.5 - 3 times faster than EX



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Loss of effectiveness

- Is there any loss of effectiveness with using direct dependency coverage?
- All failures in InterComm EX-plan maps to corresponding failure in related DD-plan
- Results show that 8 failures (how many failures overall??) from PETSc EX-plan were not detected by the related DD-plan
- Attributed to insufficient information in the model

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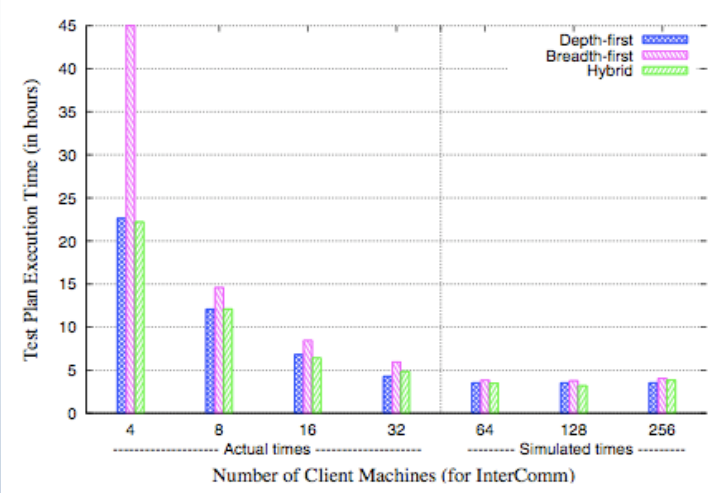
Comparison of Test Plan Strategies



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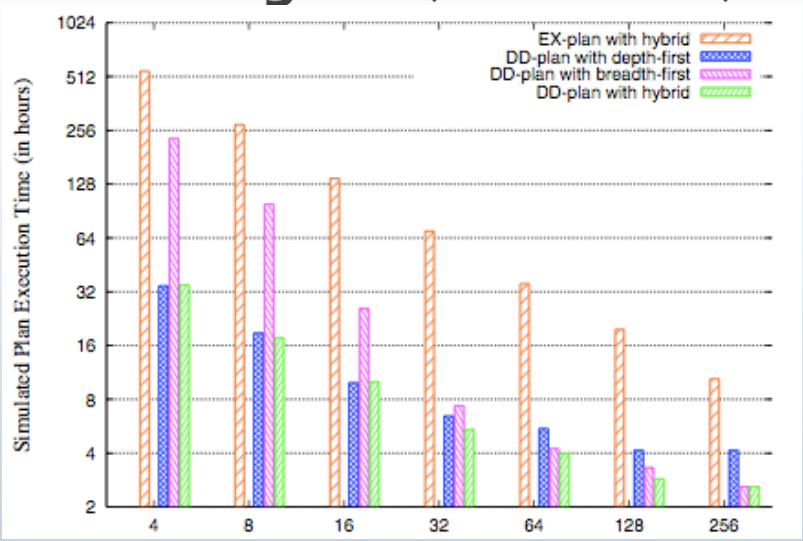
Rachet behavior as successful builds grow (simulated)



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Related Work

- GridUnit/InGrid
- Skoll and BuildFarm
- Opium and EDOS
- No industry products in this domain

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Future Work

- Further optimize plan execution strategies
- Explore new types of criteria
- Adding cost models into plan execution strategies
- Explore a way to extract dependences automatically from package tools like Automake

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Discussion

- Only good as the model
- Requires a project that uses a build tool
- Comparison of EX-Plan with DD-Plan
- Rachet can be applied to other languages

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