Automatic Undo for Cloud Management via AI Planning

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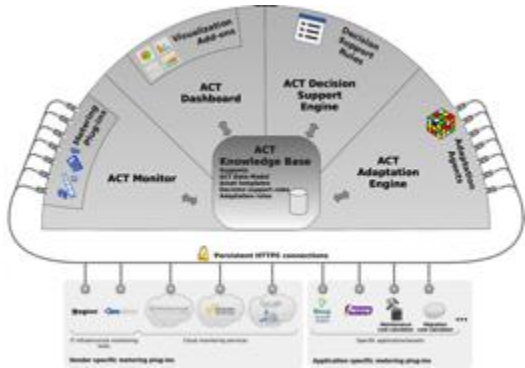
NICTA in Brief

- Australia's National Centre of Excellence in Information and Communication Technology
- Five Research Labs:
  - ATP: Australian Technology Park, Sydney
  - NRL: UNSW, Sydney
  - CRL: ANU, Canberra
  - VRL: Uni. Melbourne
  - QRL: Uni. Queensland and QUT
- 700 staff including 270 PhD students
- Budget: ~$90M/yr from Fed/State Gov and industry
- ~600 research papers/year, ~150 patents total



Yuruware our spin-out

NICTA

Bolt
your cloud deployment

Monitor
your cloud applications

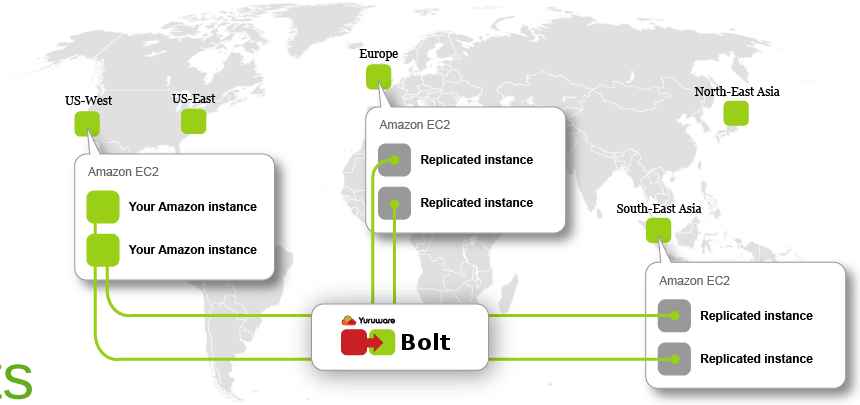
Compare
your cloud services

Clip
your idle resources

Yuruware can help…	Bolt	Monitor	Compare	Clip
Build business continuity	■			
Compare providers			■	
Monitor multiple clouds		■		
Find idle resources				■

Motivation of this work

- Yuruware Bolt: site-replication across regions
  - Executes long-running operations - create, delete and update variety resources via AWS API

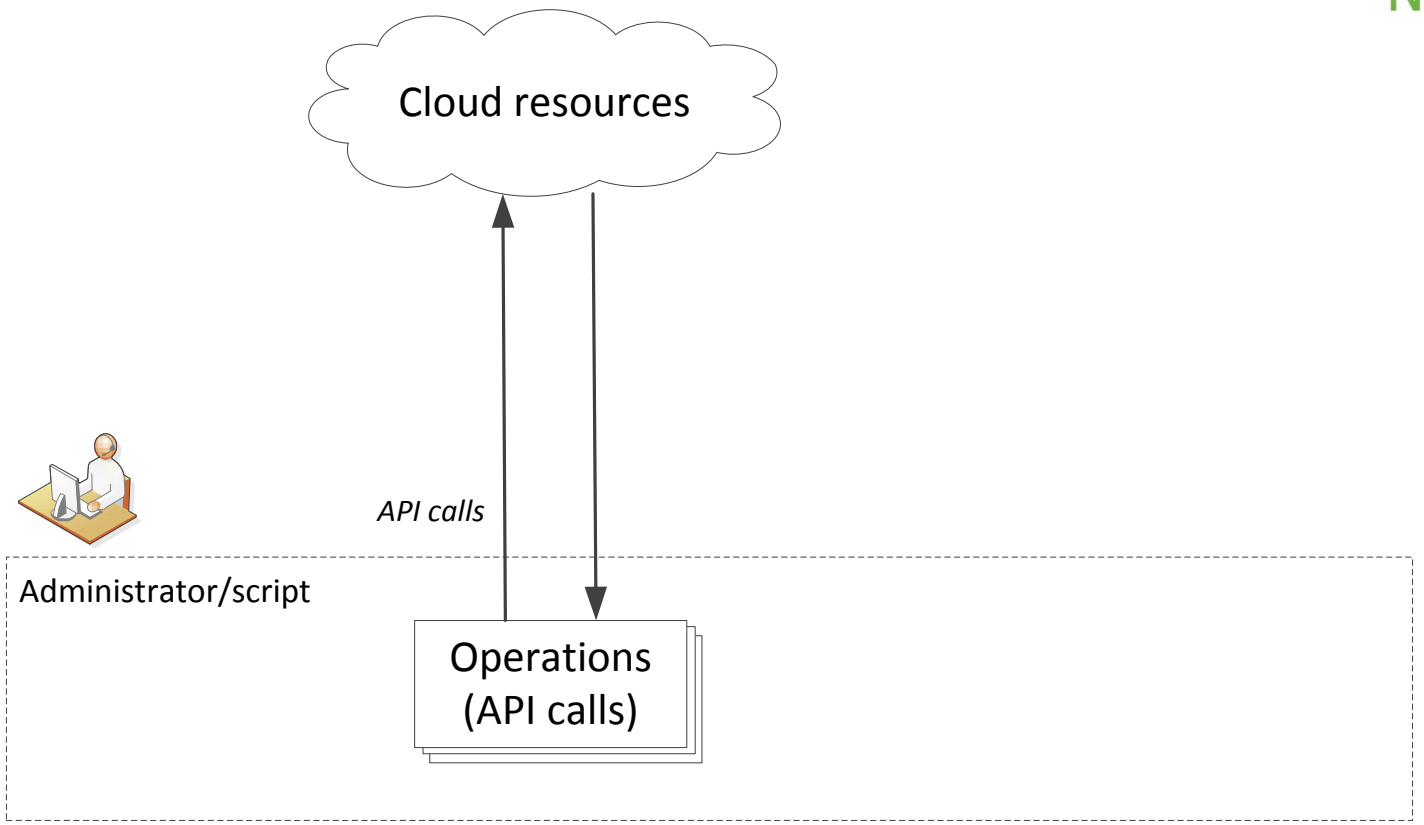


- Issues we face
  - High cost of writing unit tests
    - Preparing a test bed, reset after each test, and error recovery
    - “Why there is no DBUnit for cloud!”
  - High cost of error handling
    - Resources often get stuck in an unexpected state
    - Well-coordinated and tailored clean up for each case

Our Goal

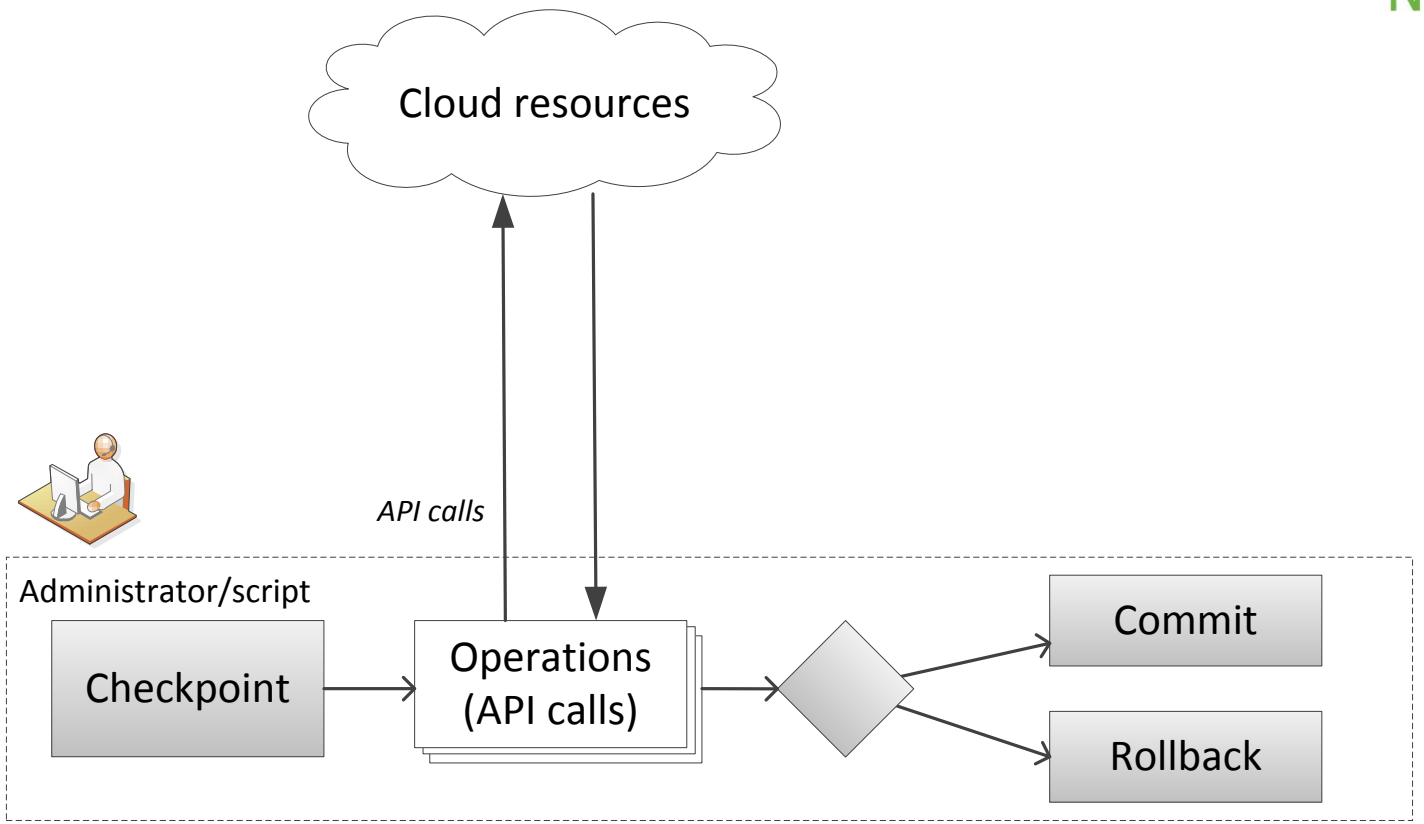
- Provide an “undo” button to cloud users
  - Allow for rolling back to a previous state
  - e.g., undelete deleted resources and reconstruct the relations among resources
- We’re users - cannot alter API or implementation
  - Some operations are undoable, e.g., detach a VIP
  - Some operations are semi-undoable, e.g., stop a VM
  - Some operations are not undoable, e.g., delete a disk
- Less invasive
  - Minimum changes in existing code or scripts

Status quo



- Administrators and/or scripts talk to cloud via API

Goal

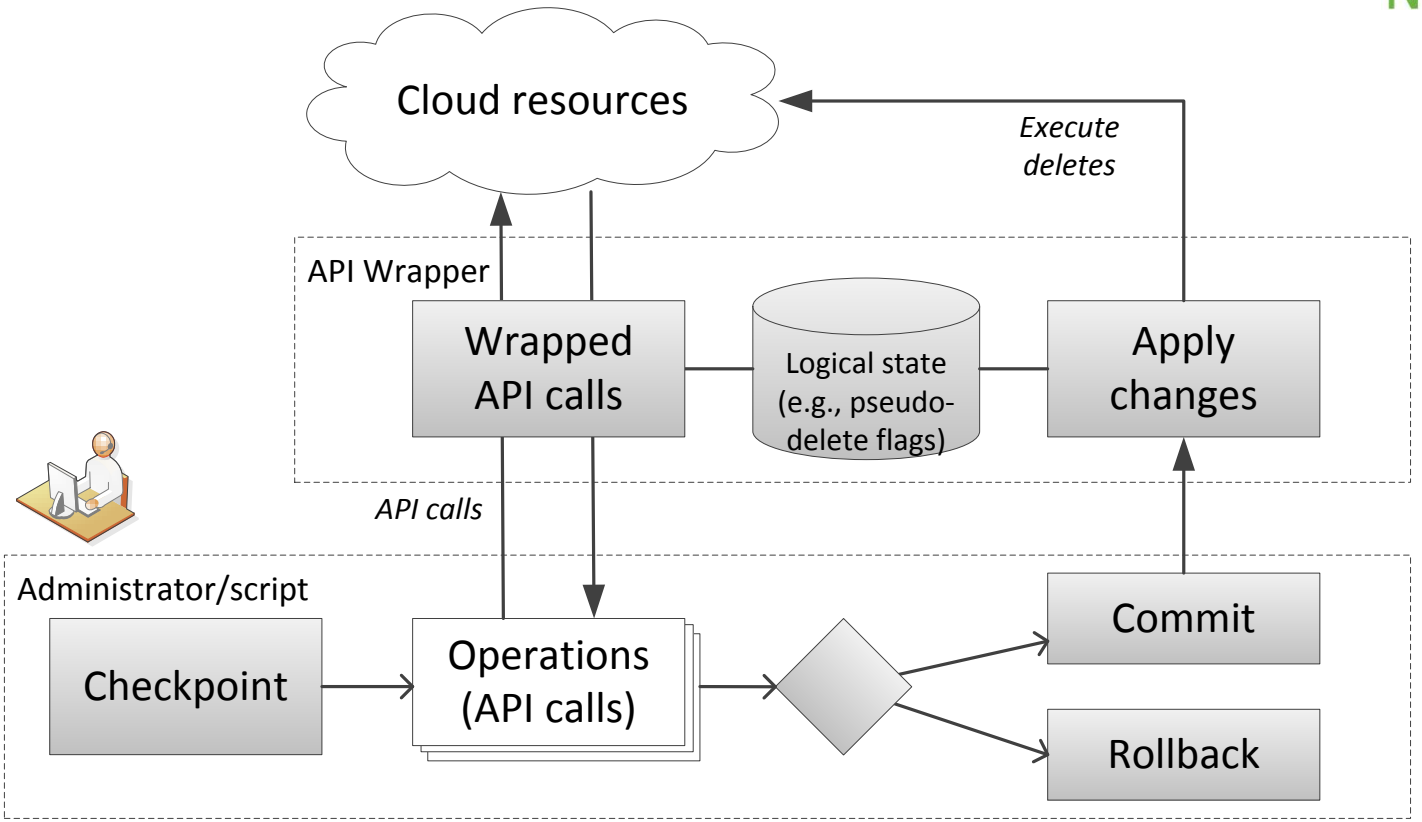


- Provide the ability to go back to a checkpoint
- No change in scripts except checkpoint and commit

Our approach

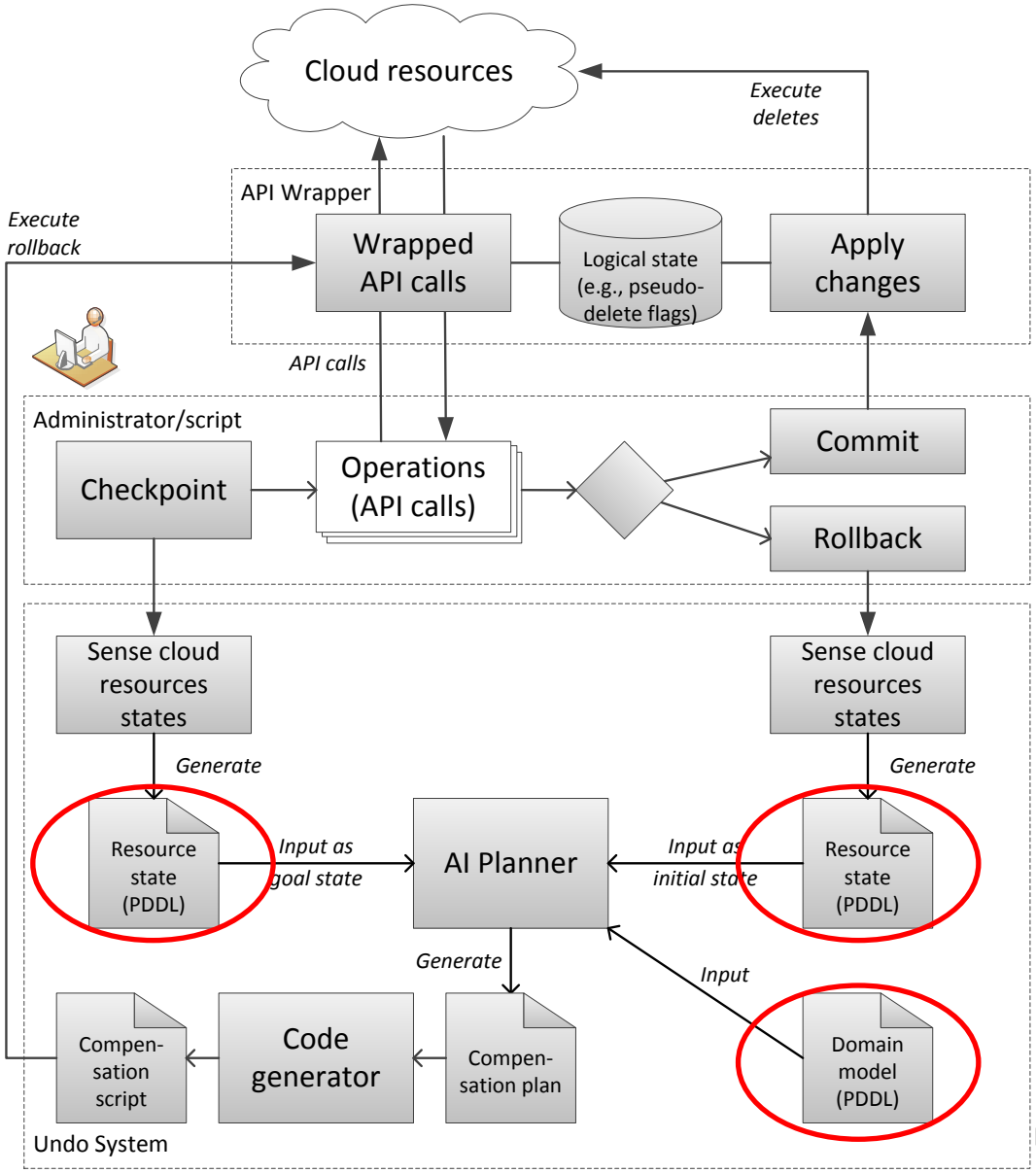
- “undo one by one in reverse order“ does not always work
  - No undo action is available
    - e.g., no “undeleteing a deleted resouce “
  - Undo requires a different sequence of API calls
    - e.g., “deleteing an autoscaling group“ does not work
  - Simple undo could results in a different state
    - e.g., Undo “stopping an instance with a VIP“
  - Undo operation may fail
    - e.g., detaching a volume could fail. Need an alternative.
  - Not optimal
    - e.g., Bolt‘s operations (creating many temporary resouces)
- Tedious to hand-code for all possible cases!

Pseudo-delete for not-undoable ops



- Execute API calls if they are undoable
- Defer the execution of non-undoable calls until commit

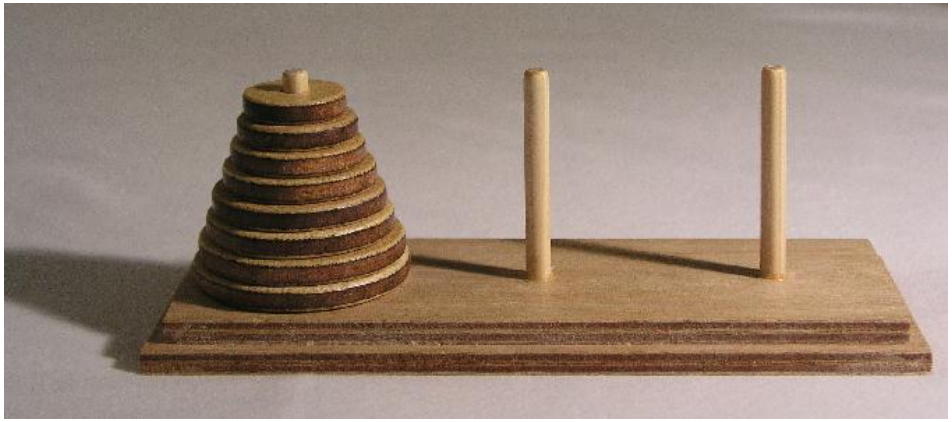
AI planning for the rest of cases



- Changes made by (semi-)undoable API calls are compensated by an AI planner
- AI planner finds ways to handle errors potentially occur during undo as well

AI Planning 101

- Given the initial state of the world, goal state, and a set of available actions, find a sequence of actions that leads from the initial to the goal



http://en.wikipedia.org/wiki/Tower_of_Hanoi

- Highly optimized heuristics tame the problem for practical purposes

Planning under uncertainty

- In our problem
  - Initial state: state at rollback
  - Goal state: state at checkpoint
  - Actions: AWS APIs
- We use FF [*] with an extension to handle actions with alternative outcomes
- Finds “maximal“ contingency plans
  - e.g., if detachnig a volume fails, stop the attached instance if possible. If a planner cannot solve, ask human intervention

[*] H OFFMANN , J., and N EBEL , B. “The FF planning system: Fast plan generation through heuristic search.” Journal of Artificial Intelligence Research, 14 (2001),

Domain model: example

- Action to delete a disk volume in PDDL

```
(:action Delete-Volume
 :parameters (?vol - tVolume)
 :precondition
 (and
   (volumeAvailable ?vol)
   (not (unrecoverableFailure ?vol)))
 :effect
 (oneof
   (and
     (deleted ?vol)
     (not (volumeAvailable ?vol)))
   (unrecoverableFailure ?vol)))
```

Domain model: actions

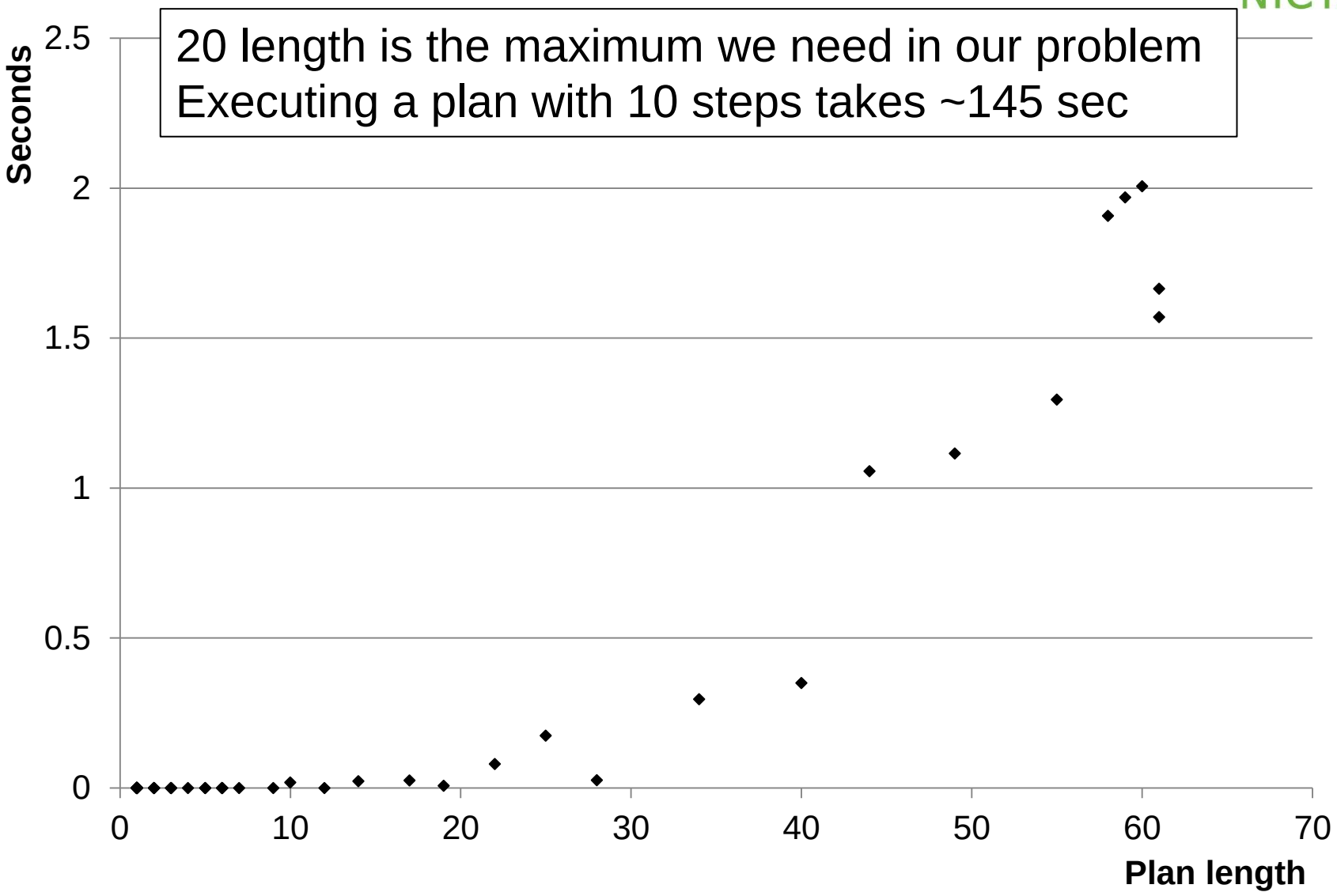
Resource type	Actions
Virtual machine	launch, terminate, start, stop, change VM size
Disk volume	create, delete, create-from-snapshot, attach, detach
Disk snapshot	create, delete
Elastic IP address	allocate, release, associate, disassociate
Security group	create, delete
Auto-scaling group	create, delete, change-sizes, change-launch-config
Auto-scaling launch config	create, delete
Tag	create, delete
Others	AZ, cluster online/offline, ...

Evaluation

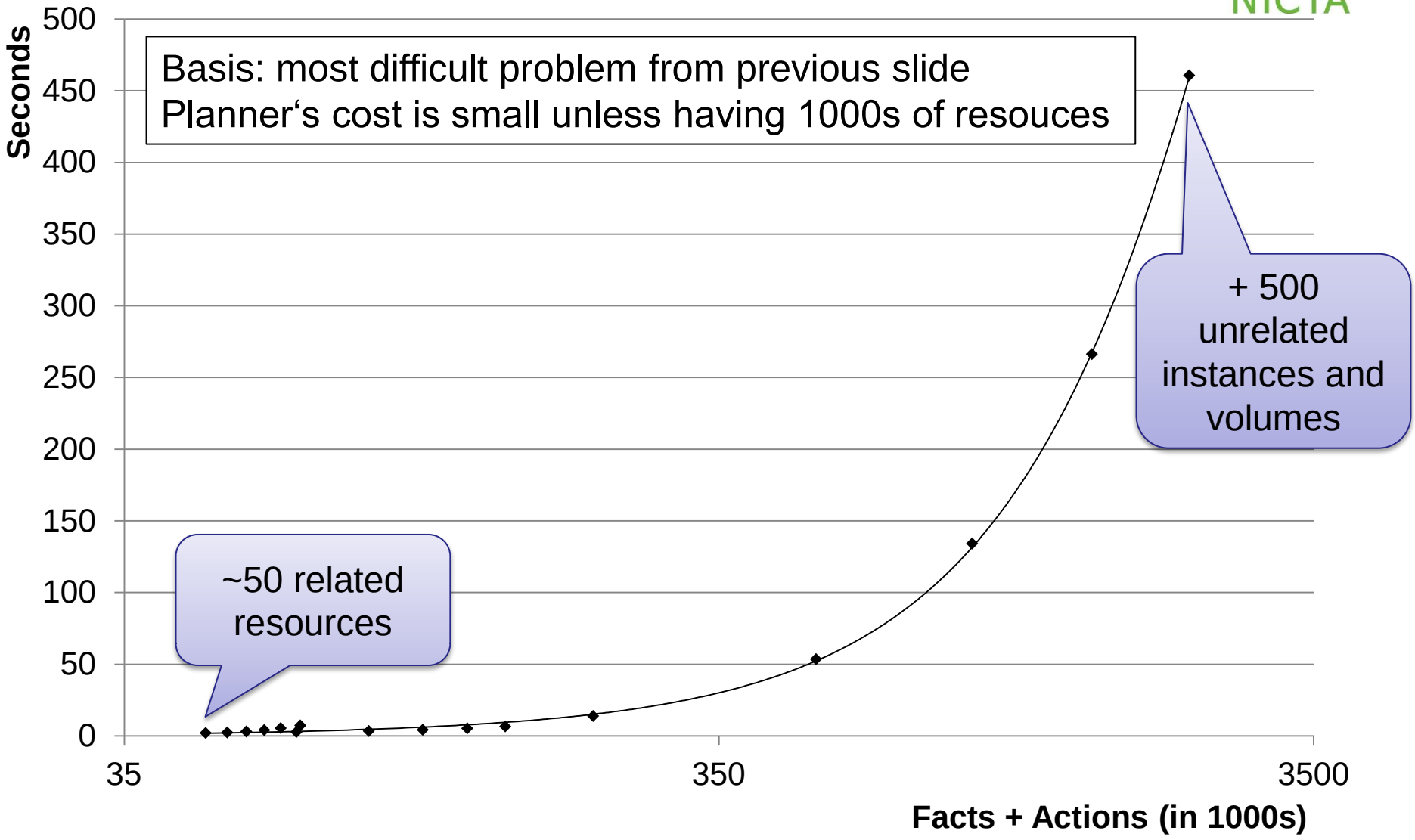
- Scalability of the planner based on an internally released prototype
  - AWS cmd line tool replacement
- Use cases: ~70 different planning settings tested

- Evaluation 1: against plan length
- Evaluation 2: against # of unrelated resources

Evaluation 1: vs plan length



Evaluation 2: vs # of unrelated resources



Conclusion & future work

- Rollback in cloud using AI planner
  - Formalized part of AWS APIs in a planning domain
  - Planning execution time is marginal for practical system sizes
- Future work
  - Extending checkpoints to capture internal resource state
  - Parallelizing plans
  - Finding forward plans with constraints

Questions?

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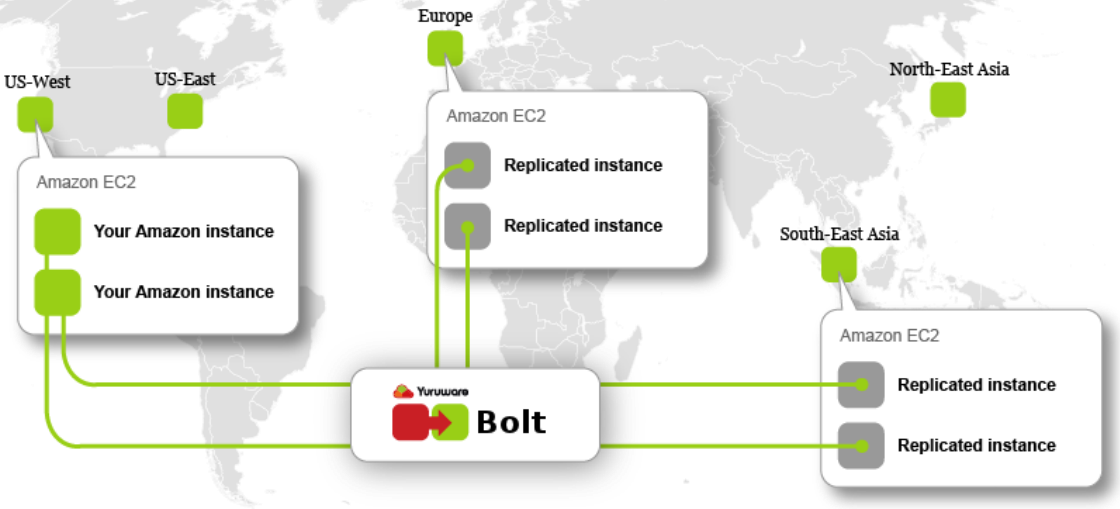
Yuruware



The paper is available at www.nicta.com.au/pub?doc=5994