Configuring Infrastructure for the Cloud

Automated planning & agents

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Background

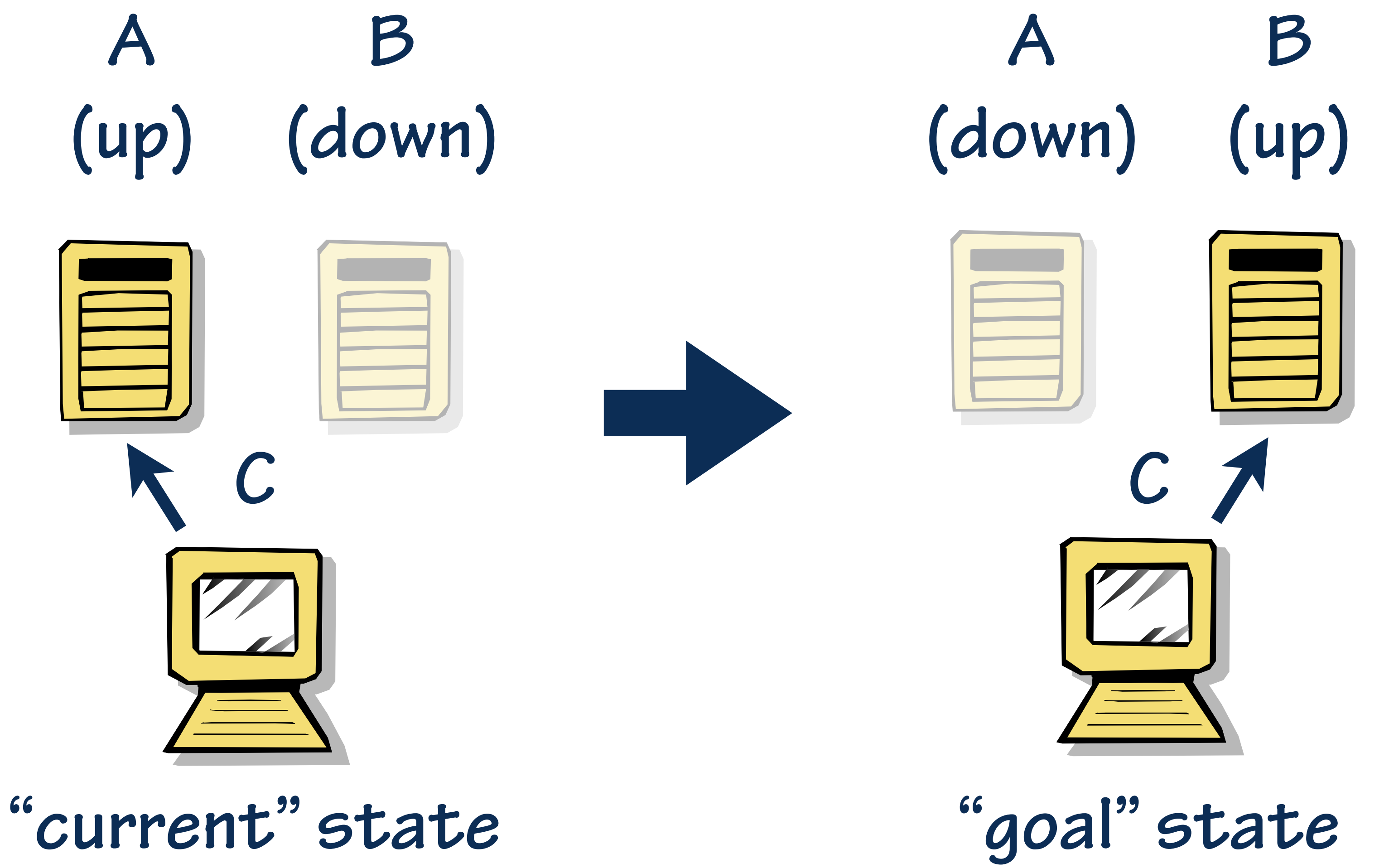
- Several different communities have an interest in configuring some aspect of computing infrastructures -
  - "System configuration", GRID, Network configuration, Application configuration ...
- Although the approaches have been slightly different, there is a lot of commonality -
  - Specification languages & policy, deployment, federated specification, security, robustness ...
- The Cloud is different only in emphasis ..
  - Less predictable, more devolved control, more opaque

Configuration Evolution

- Manual configuration
  - doesn't scale, error prone, ...
- Imperative scripts
  - scalable
  - but difficult to prove properties of resulting configuration
- Declarative specifications
  - guarantees properties of resulting configuration
  - but essentially "random" order of changes
- Stored change plans
  - declarative specifications & controlled change order
  - inflexible, unlikely to cover all requirements

Change Planning

An Example Reconfiguration

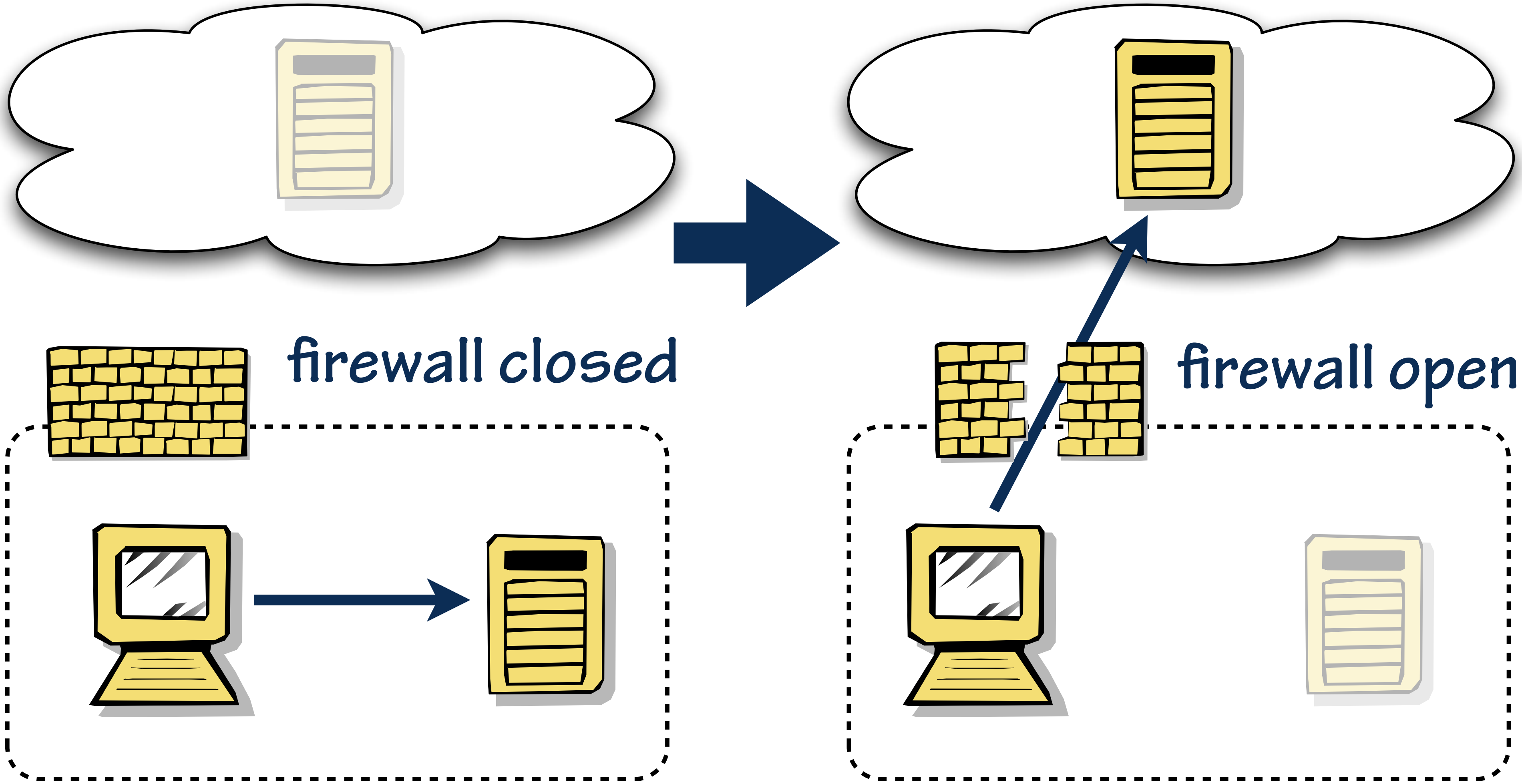


constraint: C is always attached to a server which is "up"

Possible Plans

1. A down, B up, C.server=B ✘
2. A down, C.server=B, B up ✘
3. B up, A down, C.server=B ✘
4. B up, C.server=B, A down ✔
5. C.server=B, A down, B up ✘
6. C.server=B, B up, A down ✘

“Cloudburst”

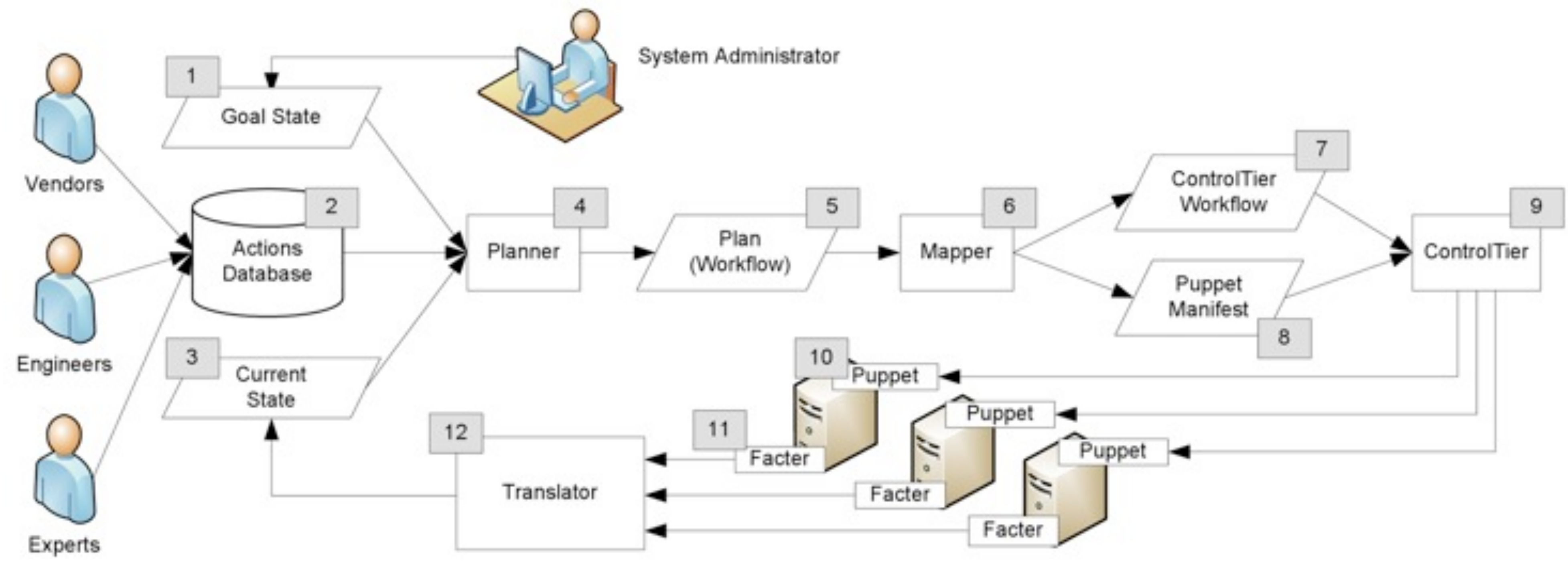


- Perhaps we need to change the DNS for the server ...
- Maybe the server needs to access internal services ...

Automated Planning

- Fixed plans cannot cover every eventuality
- We need to prove that any manual plans
  - always reach the desired goal state
  - preserve the necessary constraints during the workflow
- The environment is a constant state of flux
  - how can we be sure that the stored plans remain correct when the environment has changed?
- Automated planning solves these problems
  - but introduces others ...

Herry's Prototype



- Current state and goal state input to planner together with a database of possible actions
- Planner (LPG) creates workflow
- Plan implemented with "Controltier" & "Puppet"

Some Issues

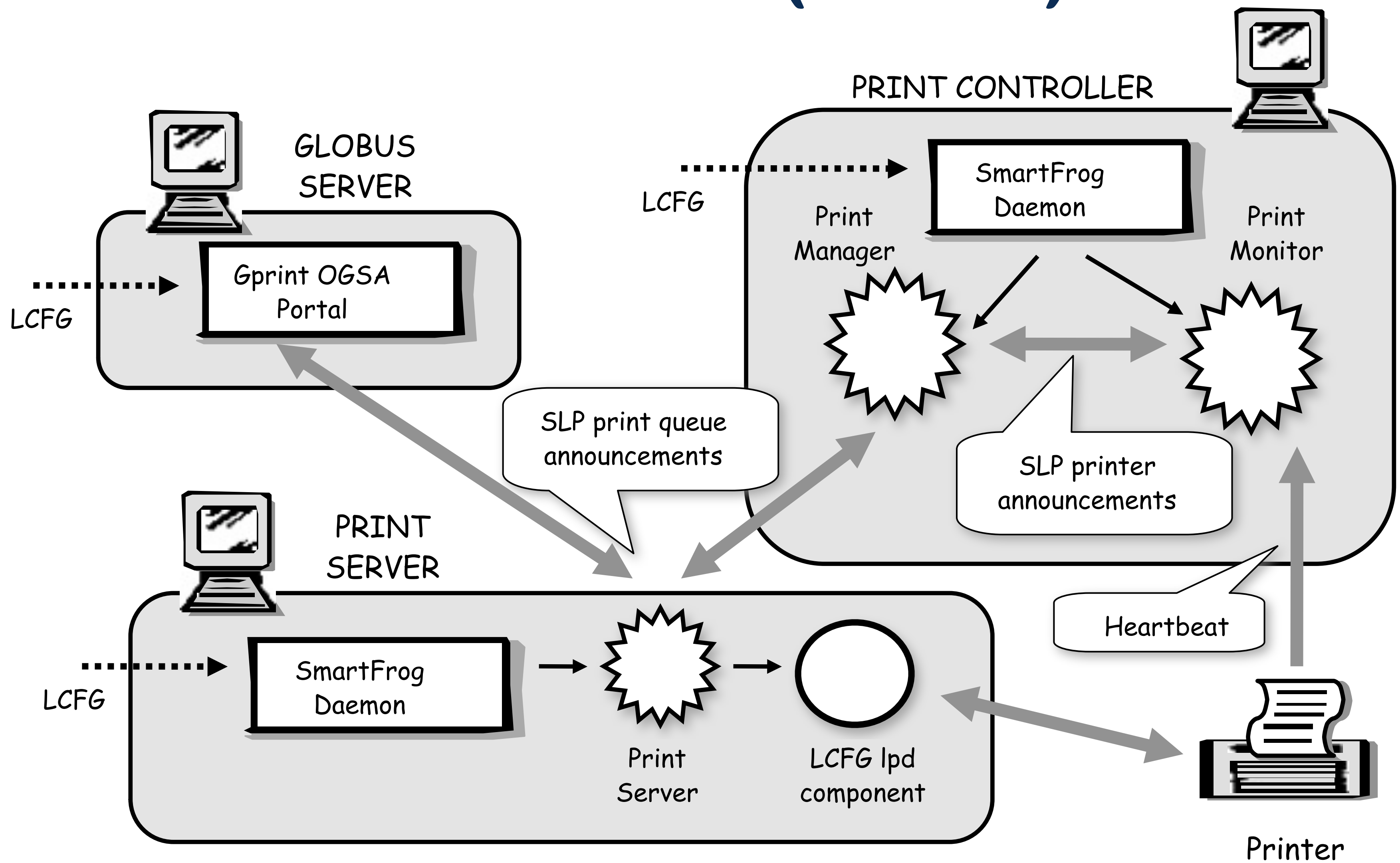
- Usability (most important!)
  - administrators are relinquishing control
  - automatic systems can often find "creative" but inappropriate solutions if some constraint is missing
- Plan repair
  - reconfigurations often occur in response to failures or overload, so the environment is unreliable
- Goals are often "soft"
  - there may be more than one acceptable goal state - usually with different levels of desirability
  - eg. "low execution time" or "least change"
- Centralised control has problems ....

Decentralised Configuration

Decentralised Configuration

- Centralised configuration
  - allows a global view with complete knowledge
- But ...
  - it is not scalable
  - it is not robust against communication failures
  - federated environments have no obvious centre
  - different security policies may apply to different subsystems
- The challenge ...
  - devolve control to an appropriately low level
  - but allow high-level policies to determine the behaviour

GPrint (2003)



- Distributed configuration with centralised policy
- Subsystem-specific mechanisms

"OpenKnowledge" & LCC

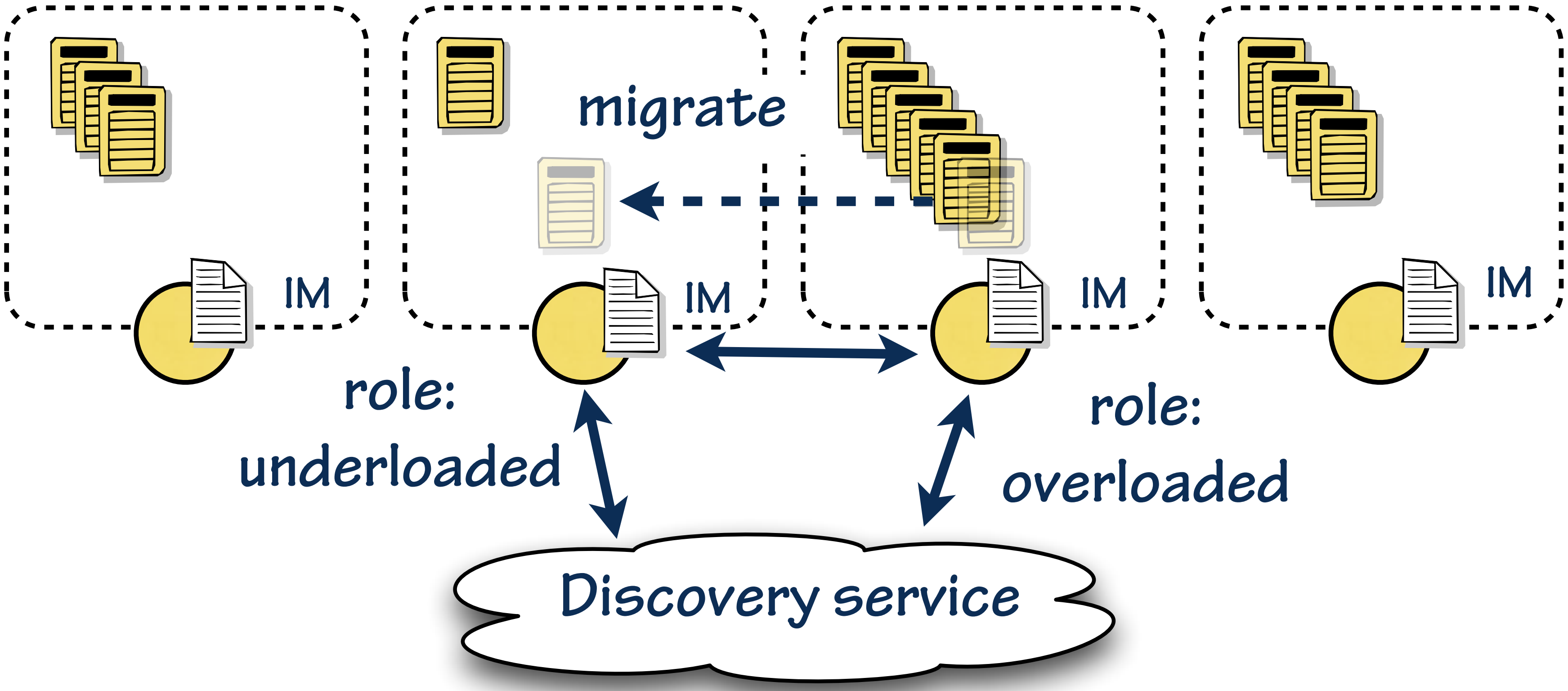
- Agents execute "interaction models"
- Written in a "lightweight coordination calculus" (LCC)
- This provides a very general mechanism for doing distributed configuration
- Policy is determined by the interaction models themselves which can be managed and distributed from a central point of control
- The choice of interaction model and the decision to participate in a particular "role" remains with the individual peer
  - and hence, the management authority

A Simple LCC Example

```
a(buyer, B) ::
 ask(X) => a(shopkeeper, S) then
 price(X,P) <= a(shopkeeper, S) then
 buy(X,P) => a(shopkeeper, S)
                ← afford(X, P) then
 sold(X,P) <= a(shopkeeper, S)

a(shopkeeper, S) ::
  ask(X) <= a(buyer, B) then
  price(X, P) => a(buyer, B)
                   ← in_stock(X, P)then
  buy(X,P) <= a(buyer, B) then
  sold(X, P) => a(buyer, B)
```

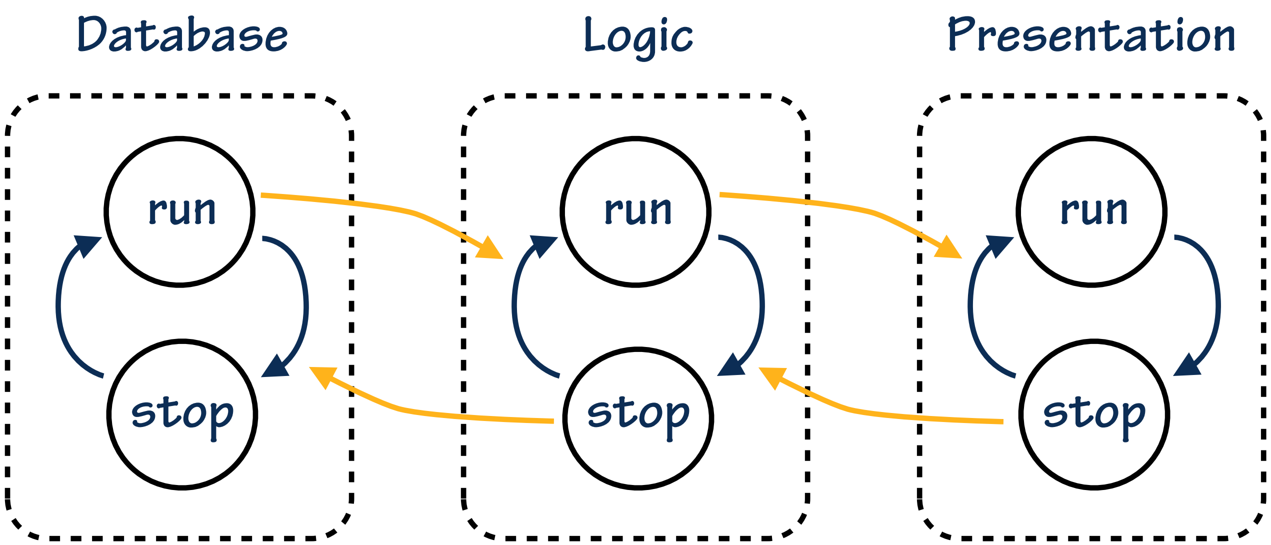
An Example: VM Allocation



- Policy 1 - power saving
  - pack VMs onto the minimum number of physical machines
- Policy 2 - agility
  - maintain an even loading across the physical machines

Distributed Planning for Configuration Changes

Behavioural Signatures



- Blue transitions are only enabled when the connected component is in the appropriate state
  - simple plans execute autonomously
- The plan executes in a distributed way
- The components are currently connected manually
  - and the behaviour needs to be proven correct in all cases

Planning with BSigs
(Herry's current Phd work)

- If we have ...
  - a set of components whose behaviour is described by behavioural signatures
  - a "current" and a "goal" state
- We can use an automated planner to generate a network of components to execute a plan which will transition between the required states
- Some interesting possibilities
  - this can be structured hierarchically
  - the plans may not be fixed
    ie. they could handle some conditionals and errors

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- http://homepages.inf.ed.ac.uk/dcspaul/publications/kes2011-slides.pdf

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