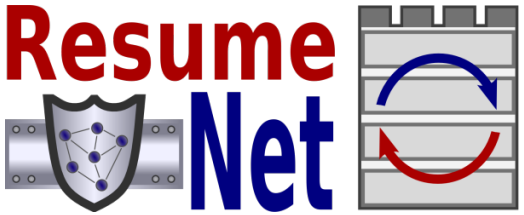


Resilience in Networks: Elements and Approach for a Trustworthy Infrastructure

Andreas Fischer and Hermann de Meer

The ResumeNet project

- Resilience & Survivability for future networking framework, mechanisms & exp. evaluation
- Contract number: FP7 – 224619
- Effort
  - 36 months (Sep 2008 – Aug 2011)
  - 437 person-months
  - Equivalent of 12 scientists working full-time

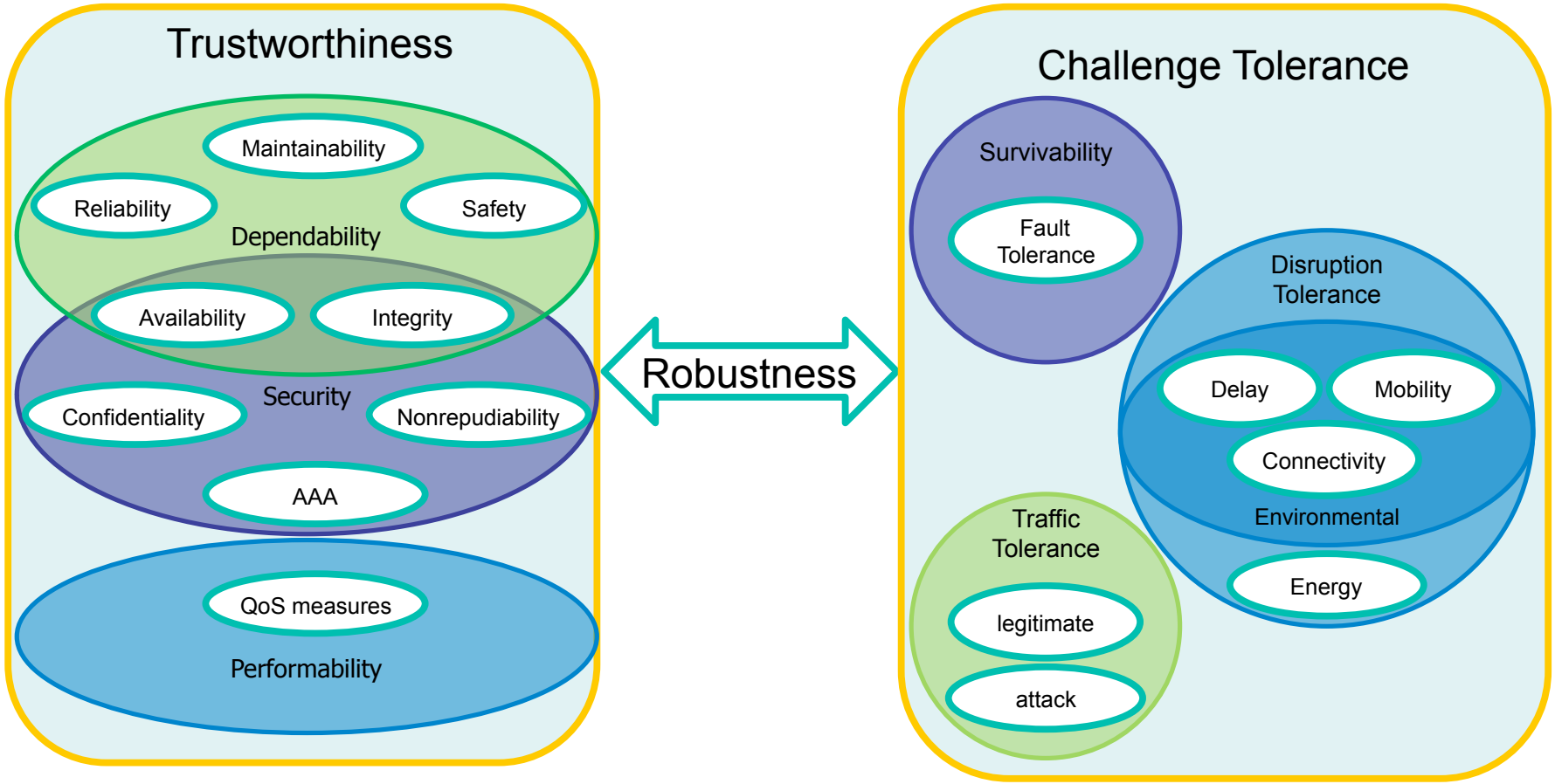
- Partners

Swiss Federal Institute of Technology
Lancaster University
Munich University of Technology
France Telecom
NEC Europe Ltd.
University of Passau
Delft University of Technology
University of Uppsala
University of Liege

- Website: http://www.resumenet.eu/

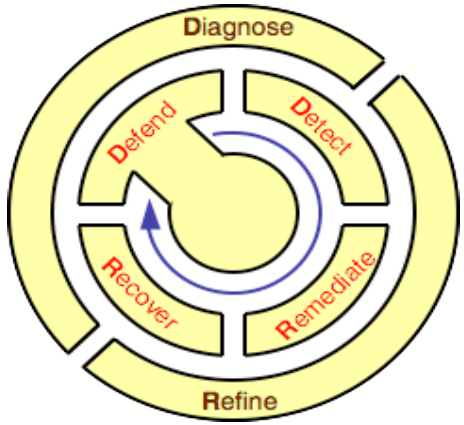
What is network resilience?

"The ability of the network to provide and maintain an acceptable level of service in the face of various faults and challenges."

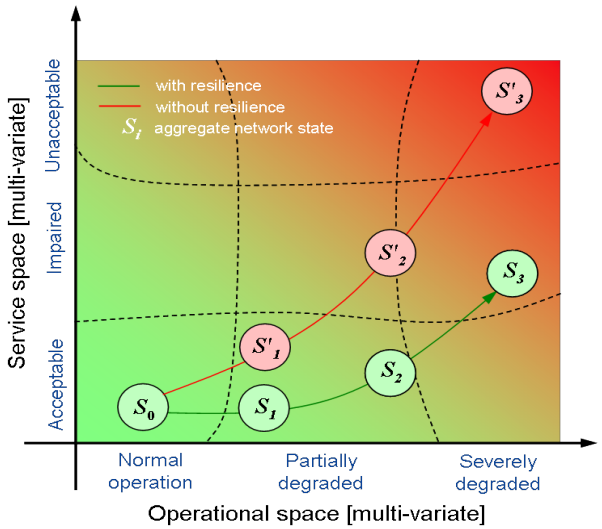


The ResumeNet approach to resilience

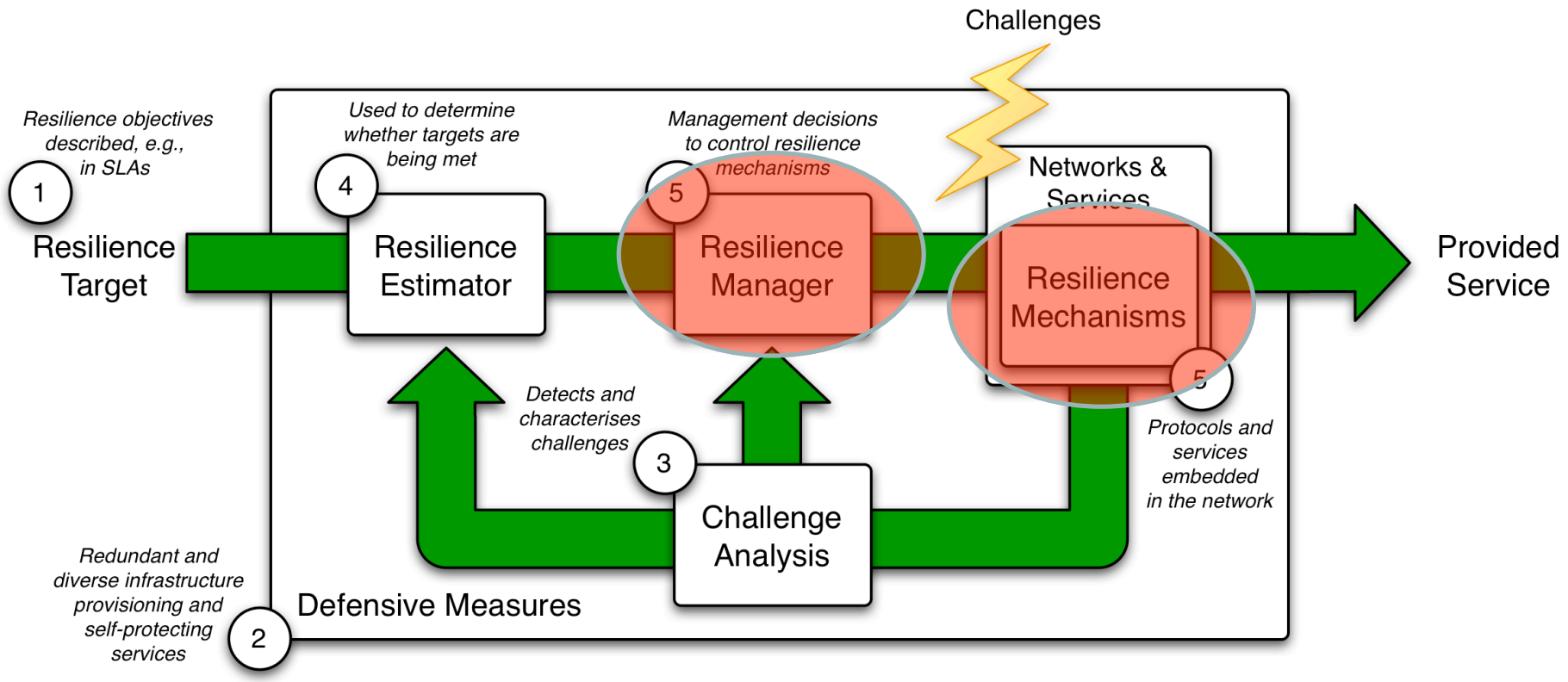
- Resilient Networking Architecture – D²R²+DR
  - Defend, Detect, Remediate, Repair
    - Real-time control loop
    - React to changes of the network
  - Diagnosis and Refinement
    - Long-term actions
    - Improve overall resilience



- Network and Service Resilience
  - Service: Acceptable, impaired, unacceptable
  - Network: Normal, partially, severely degraded



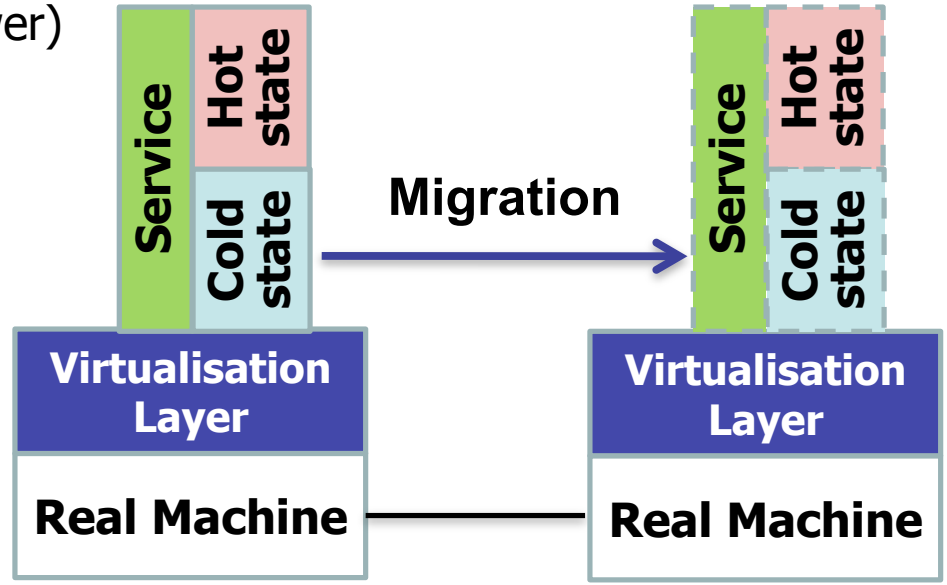
Resilience Control Loop



Virtual service migration

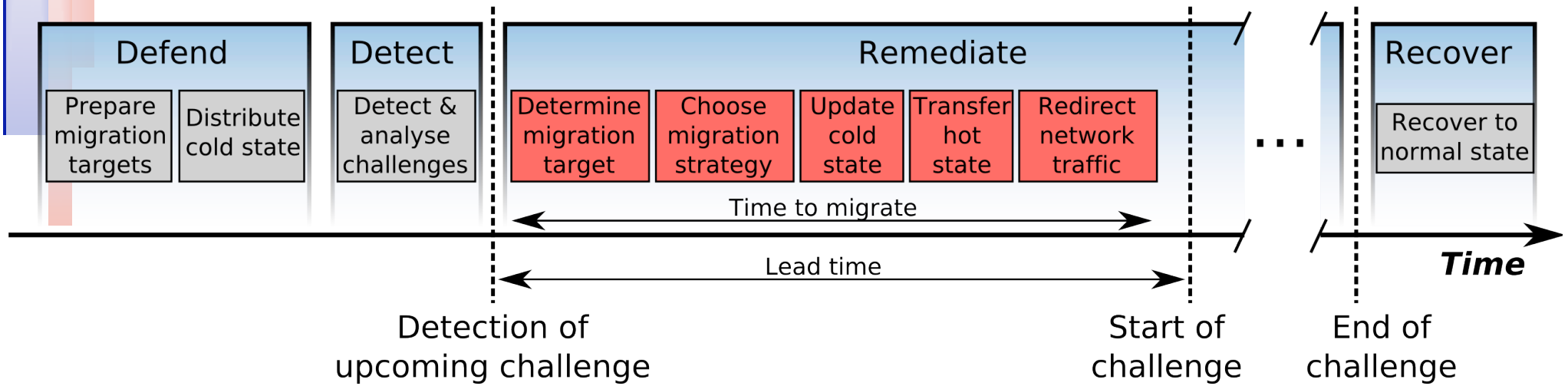
- Use service virtualisation as resilience enabler
  - Virtualisation enables migration of arbitrary network services
  - Counter certain types of challenges
    - Hardware destruction (e.g. due to natural disaster)
    - Communication environment (e.g. unreliable link)
    - Unusual but legitimate requests for service (e.g. insufficient CPU power)
- Advantages
  - Flexible reaction to challenges
  - (Mostly) transparent to services
- Problems
  - Limitation of time
  - Limitation of resources

ENISA, Cloud Computing research problems:
•Long distance live migration of virtual machines
•Resilience of Cloud Computing



Virtual Service migration phases

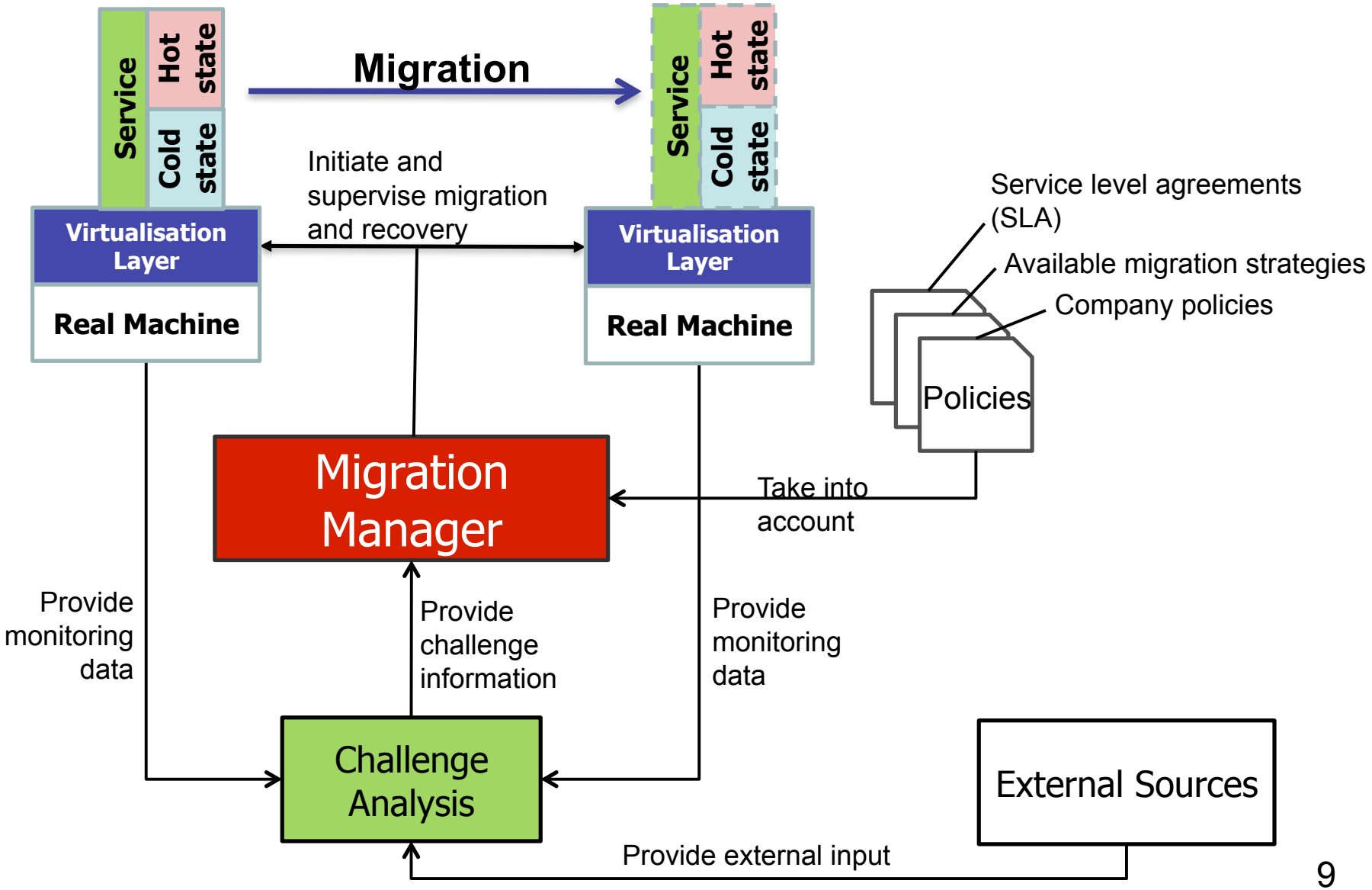
- Dynamic Composite Service Migration
  - Compose migration from distinct actions (migration primitives)
  - Separate migration of service primitives
- Overall goal: Keeping service operational during challenge



State transfer strategies

Strategy	Description	Pros	Cons	State lost?	Applicable scenario
None	No migration	No changes introduced	No resilience introduced	All state is lost	No spare resources available
Cold spare	Don't transfer hot state, fall back to cold state	Simple, fast, works with disconnected source & dest.	Does not keep hot state	Hot state is lost	Hardware fails unexpectedly
Cold migration: Stop and copy	On challenge detection: Stop service, copy all state, restart on target machine	Simple	Significant service downtime	State is kept	Service downtime acceptable, challenge still some time off
Cold migration: Update hot state	Initially distribute cold state. On chall. det.: Stop service, copy hot state, restart on target machine	Simple, total time to recovery only dependent on size of hot state	Requires initial distribution and regular update of cold state	State is kept	Small service downtime acceptable, challenge pending
Live migration: Continuous state update	Start service on target host and continuously synchronize state	Almost no service downtime	Complex, uses unnecessary bandwidth, high total time to repair	State is kept	Service downtime should be minimized
Live migration: Update state on demand	Start service on target, transfer state as needed	Low service downtime, state is copied only once	Complex, very high total time to repair	State is kept	Initially low service response time is acceptable
Hot spare	Synchronize all state during operation	No service downtime	Very complex, uses resources even in absence of challenges	State is kept	Critical service – no downtime acceptable

Virtual Service migration for resilience



Conclusions

- Resilience is a wide topic
  - Tackles important Future Internet issues
  - Needs an understanding of challenges
  - Needs a coordinated approach
- D^2R^2+DR provides a design guideline
  - Systematic approach to resilience
  - Blueprint for designing resilient systems