4th Grenoble Workshop on Autonomic Computing and Control

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supported by HPES project of ANR Persyval-lab

Outline

- Intro : Autonomic Computing, feedback loops and control
- Some past and ongoing loops
- Programme

Ctrl-A team : Control for Autonomic Computing

Automated administration & **regulation**

in **reaction to variations** in load,

resources,… in **large** (Big Data) or

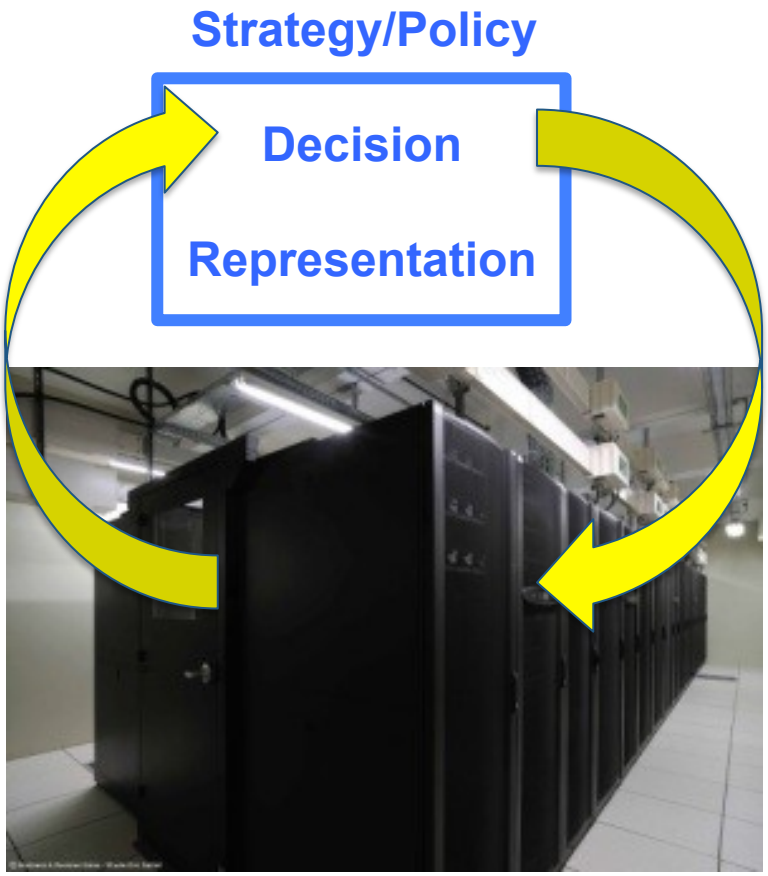
embedded (IoT) **systems**

promising, but
challenge in developing applications
need for **automation**
& **separation of concerns**

Understand and design control for

problems in **efficiency** (e.g; energy)

& **assurances** (e.g.crash avoidance)



Eolas, Grenoble

Motivation

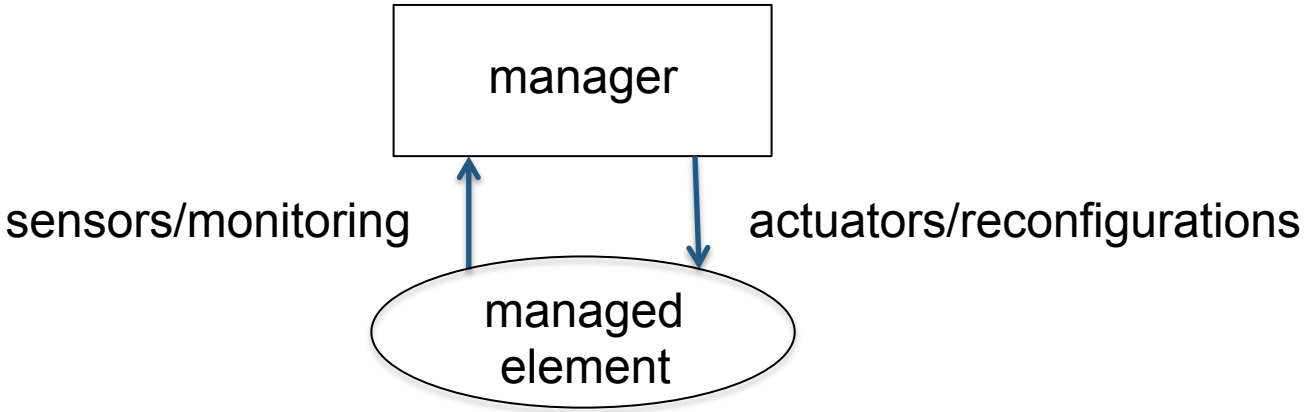
- **Our approach:** Software Engineering :
  - **Middleware-level** instrumentation and architectures,
  - **Model-based control (Discrete Event Systems)**,
  - **Programming support (reactive, components)**

- **Targets : HPC, IoT** coarse grain, mid-size, heterogeneity
  problems : navigation in configurations space
- **Method** : propose generic **models** and **validate** them
  to attack lack of models & wide range of problems
- **Multidisciplinarity** : autonomic computing, languages
  + control theory, target platforms (HW/SW)

- **Our goal: languages** & model-based Softw. Eng. **methods validated** in target domains : HPC, reconfigurable arch., IoT

Autonomic Computing feedback loop

interfaces between managed element and manager
objective to be enforced by the manager, **using Control Theory**
self-configuration, self-optimization, self-healing, self-protection
knowledge/model of the managed element used by the manager
pace at which decisions are made (frequency, event-based)



Marin Litoiu, Mary Shaw, Gabriel Tamura, Norha M. Villegas, Hausi Müller, Holger Giese, Romain Rouvoy, Eric Rutten. *What Can Control Theory Teach Us About Assurances in Self-Adaptive Software Systems?* in SefSas 3, **LNCS 9640, 2017**

Nicolas Berthier, Éric Rutten, Noël De Palma, Soguy Mak-Karé Gueye. *Designing Autonomic Management Systems by using Reactive Control Techniques.* IEEE Transactions on Software Engineering (**TSE**), **2016**, 42 (7)

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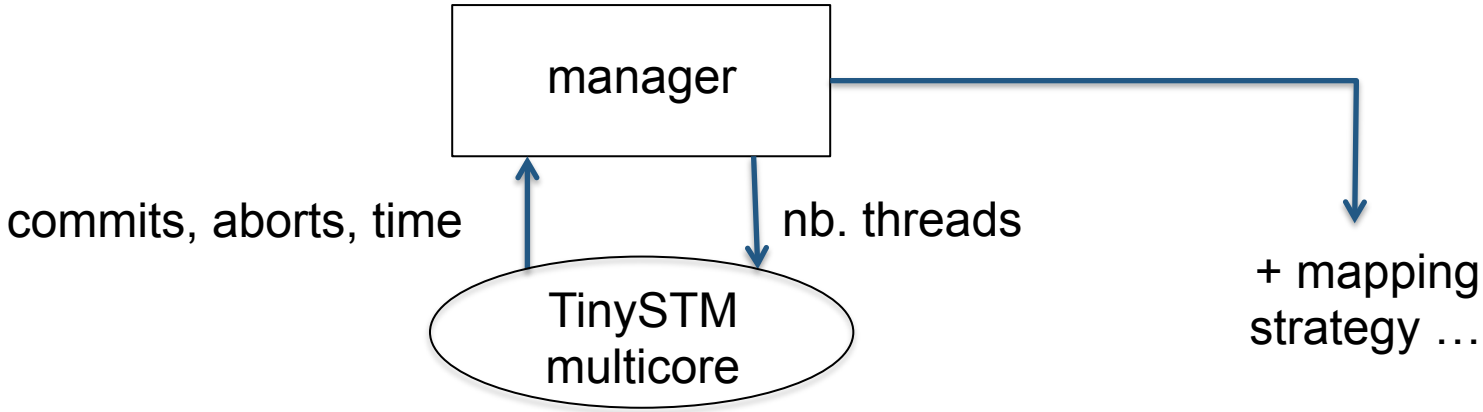
Parallelism/synchronization trade-off in STM

intuition lower parallelism when synchronization cost increases
interfaces sensors : commits, aborts, time; actuator : nb. threads
objective maximize thoughput (commits/time)
knowledge/model commit ratio CR = commits/(commits+aborts)
probabilistic model : nopt = −(n−1) / ln CR
pace when CR changes by more than X%

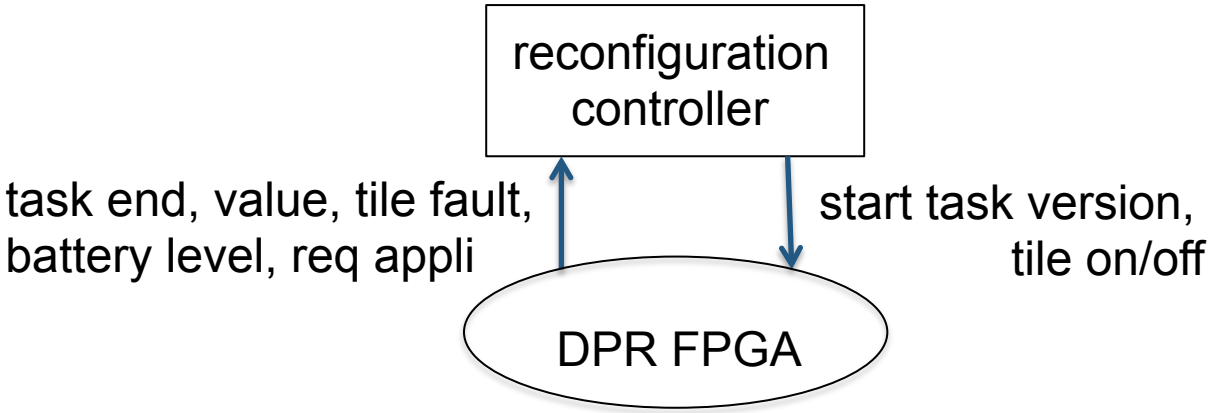


HPES project in ANR Persyval-lab

N. Zhou, G. Delaval, B. Robu, E. Rutten, J.-F. Mehaut. *Autonomic Parallelism and Thread Mapping Control on Software Transactional Memory* **(ICAC 2016)**

DPR FPGA reconfiguration control

intuition change bitstreams according to application/environment
interfaces sensors : progress and environment events ;
actuator : choice of bitstreams to execute, tile on/off
objective maintain QoS while minimizing resources
knowledge/model configuration states space (FSM) : tasks versions w. different characteristics/costs, application DAG
pace when event

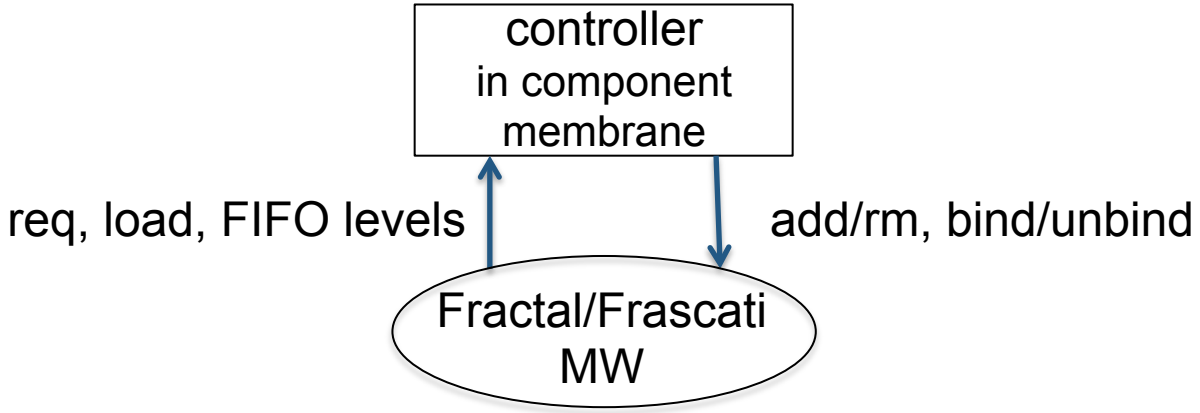


new project ANR HPeC

X. An, E. Rutten, J.-P. Diguet, A. Gamatié. *Model-based synthesis of correct controllers for dynamically reconfigurable architectures* **ACM TECS** 2016

Software components reconfiguration

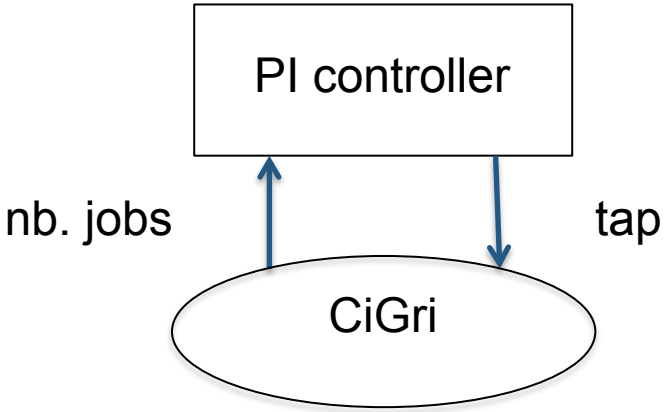
intuition reconfigure component assemblies (instances, bindings)
interfaces sensors : applicative, FIFO levels, …
actuators : actions on components/composites
objective for Comanche server : avoid overload, logging/caching
knowledge/model components versions/implems, DSL & contracts incl., composites assembly configurations (FSM)
pace when event



T. Bouhadiba, Q. Sabah, G. Delaval, E. Rutten. *Synchronous Control of Reconfiguration in Fractal Component-based Systems – a Case Study* **EMSOFT'11**
Frederico Alvares, Eric Rutten, Lionel Seinturier. *A Domain-specific Language for The Control of Self-adaptive Component-based Architecture*, **Journal of Systems and Software, 2017**

Overload avoidance in a HPC cluster

intuition regulate jobs sent according to load
interfaces sensor : current number of jobs processed ;
actuator : max. number of new jobs to be sent to the cluster
objective maximize cluster utilization while avoiding overload
knowledge/model identification ; PI controller
pace periodic

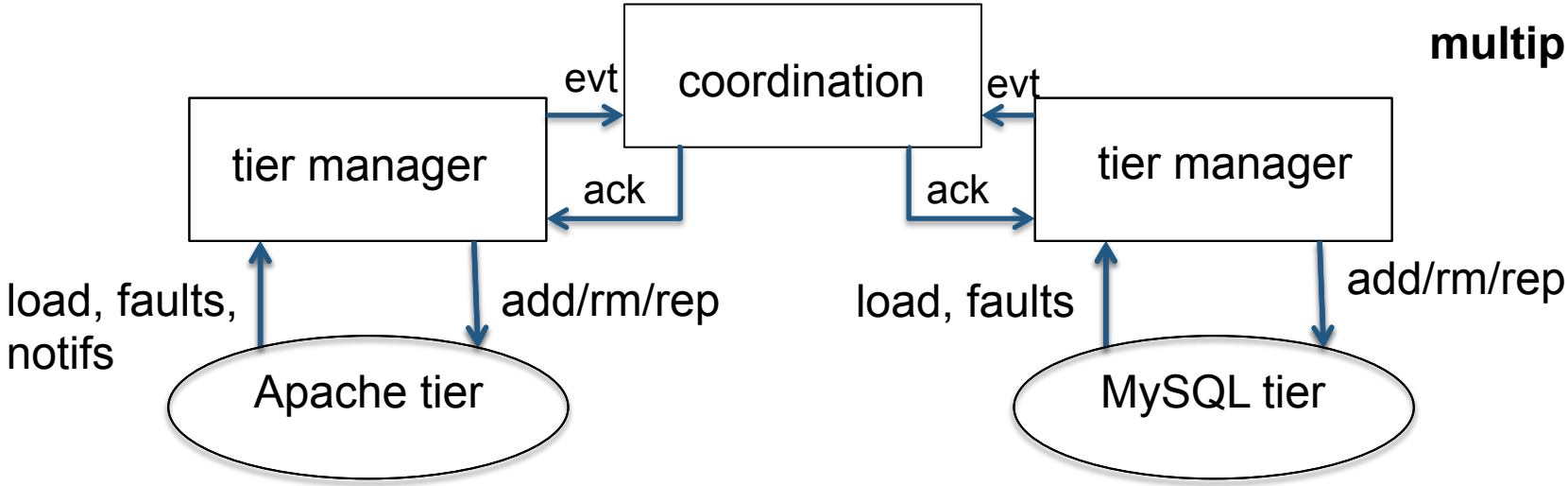


E. Stahl, S. Gueye, O. Richard, B. Bzeznik, B. Robu, E. Rutten. *Towards a Control-Theory based approach for cluster overload avoidance.* E. Stahl, MSc thesis, 2017

Coordinating sizing & repair in Multi-tiers

intuition avoid interference/redundancies between loops
interfaces sensor : load, faults ; manager activity
actuator : add/rm server ; suspend manager action
objective suspend downstream mgrs when upstream busy
knowledge/model activity state of mgrs (FSM)
pace when event

multiple loops



S. Gueye, N. de Palma, E. Rutten, A. Tchana, N. Berthier. *Coordinating self-sizing and self-repair Managers for Multi-tier Systems*. **jFGCS** 2014

Conclusion

- feedback loops are all around
- control techniques are there to design

  efficient and well-mastered

  autonomic managers
- a variety of loops : differences and

  commonalities, some know-how, ...

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