Efficient and Safe Distributed Software Commissioning and Reconfiguration

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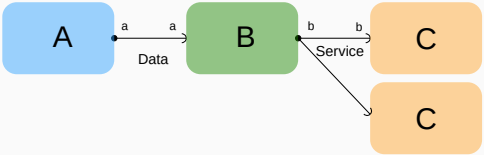
2019-12-09 Tromsø

Distributed software



- Modules, services or components
  - running on distributed machines interconnected by a network
- Connections, communications
  - cooperating to get a result
- Examples: micro-services- and service-oriented software systems, MPI applications, CORBA applications, systems of systems etc.

Component management

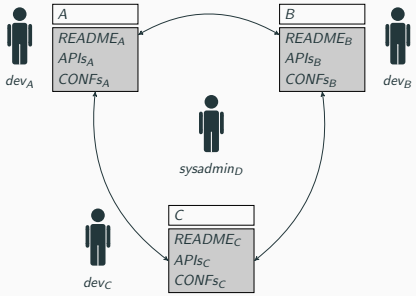
Code (development) ✓

- already existing code and communications

DevOps (management) ✗

- Control APIs on the component (start, backup etc.)
- Configuration files to get infra parameters (sysadmins)
- README file (or webpage)
  - uses both control APIs and configuration files
  - description of procedures (install, stop, update etc.)
  - commissioning procedure: requirements (libraries, packages etc.), configurations, order of execution, testing the commissioning sucess

Distributed software commissioning and reconfiguration



- dev$_A$, dev$_B$ and dev$_C$ write the APIs, the configuration files and the README for their components
- sysadmin$_D$ has to
  - coordinate the READMEs of all components
  - webpages/scripts to explain this kind of complex commissionings (example)

Challenges

- Languages and models for commissioning and reconfiguration
  - Software Engineering (SE) properties: composition, code-reuse, separation of concerns etc.
- Safety of commissionings and reconfigurations
- Efficiency of commissionings and reconfigurations

Limitations of DevOps tools

- no formal model, no guarantees
- limited composition and separation of concerns
- limited efficiency

Limitations of academic related work

- limited separation of concerns
- limited efficiency

Contributions

1. Madeus: formal model to adress the efficient coordination of commissioning procedures
   - *Maverick Chardet, Hélène Coullon, Christian Perez and Dimitri Pertin. Madeus: A formal deployment model. In 4PAD 2018 (hosted at HPCS 2018), Jul. 2018, Orléans, France.*
   - Journal under submission
2. MADA: Study the use of model checking to help in the design of safe and efficient distributed software commissioning with Madeus
   - *Hélène Coullon, Claude Jard and Didier Lime. Integrated Model-checking for the Design of Safe and Efficient Distributed Software Commissioning. In iFM 2019, Dec. 2019, Bergen, Norway.*
3. Concerto: A generalization of Madeus to (re)configuration of distributed software systems
   - Under submission

Table of contents

Distributed software commissioning: Madeus

Madeus principles

- separation of concerns: $\text{dev}_{\text{assembly}}$ does not need to know details about each component
- more parallelism in the commissioning language
- automatic coordination, correct order of execution, automatic parallelism

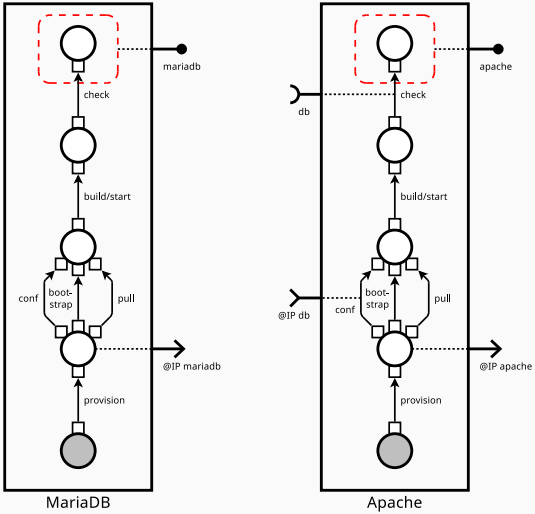
Why efficiency in distributed software commissioning?

- scripts executed many times by sysadmins
- continuous integration of big projects
- first step toward efficient reconfiguration

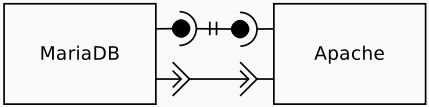
Madeus contributions

- a formal model and its operational semantics
- a theoretical performance model
- an open-source prototype (`https://gitlab.inria.fr/VeRDi-project/concerto/tree/master/concerto/madeus`)
- an evaluation on a real use-case OpenStack
  - reproducible/repeatable research
  - `https://gitlab.inria.fr/VeRDi-project/madeus-openstack`
  - `https://gitlab.inria.fr/VeRDi-project/madeus-openstack-benchmarks`

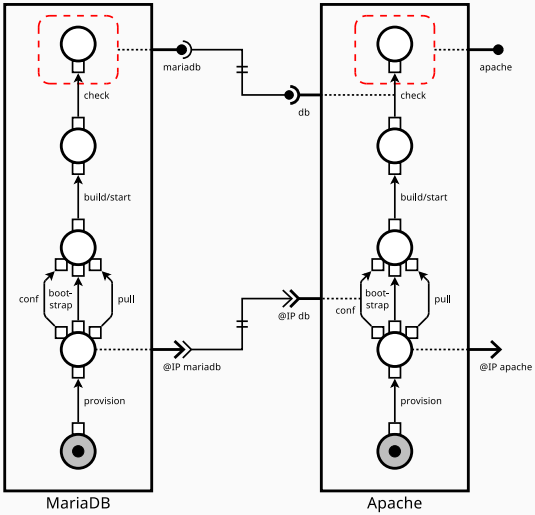
Madeus - control component (1/2)



Madeus - composition and assembly (2/2)



Madeus execution



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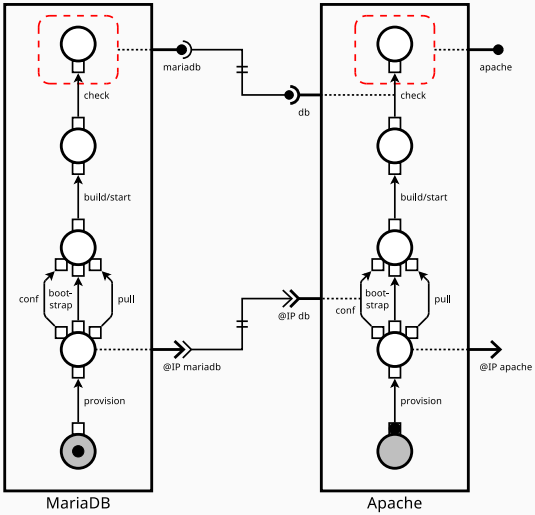

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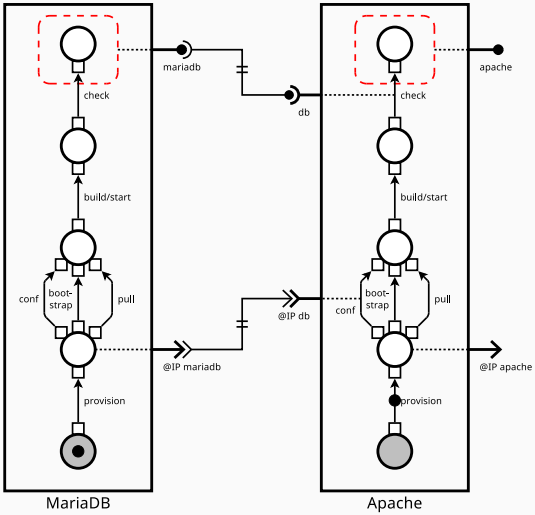

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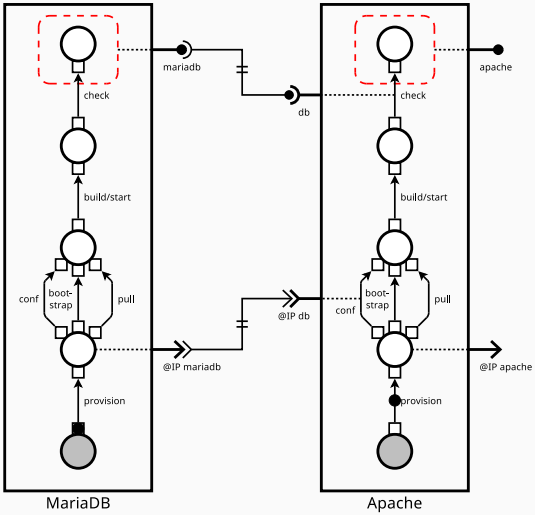

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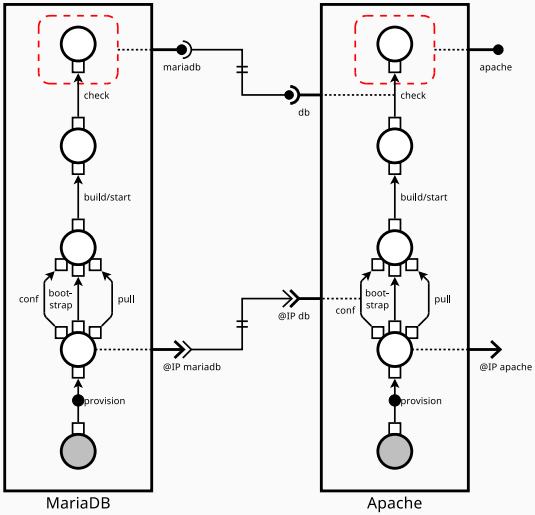

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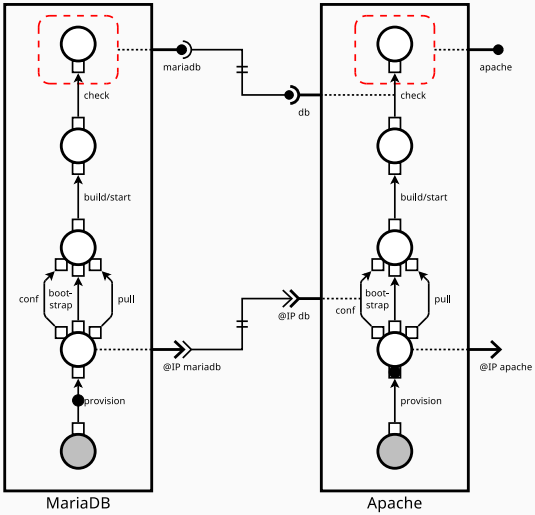

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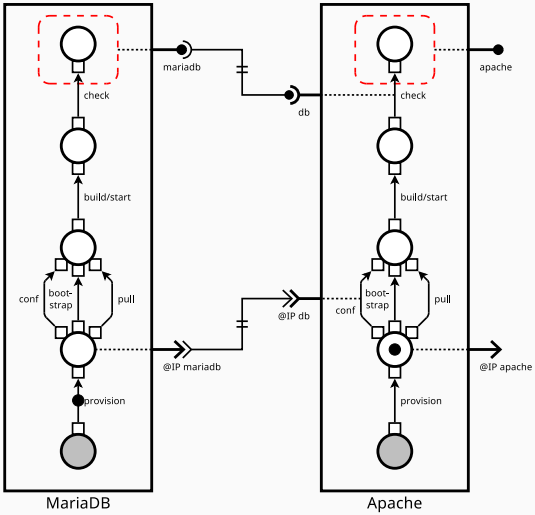

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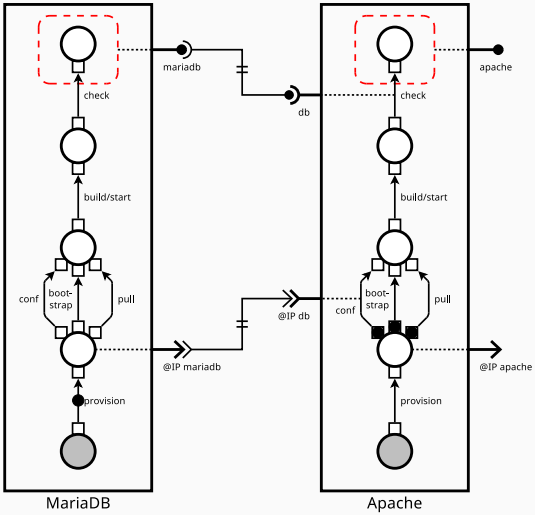

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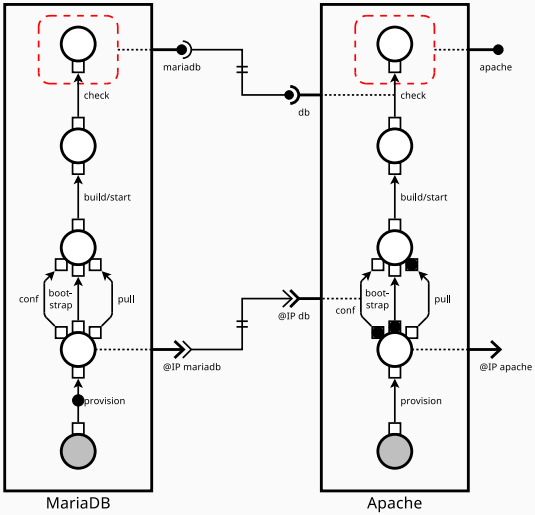

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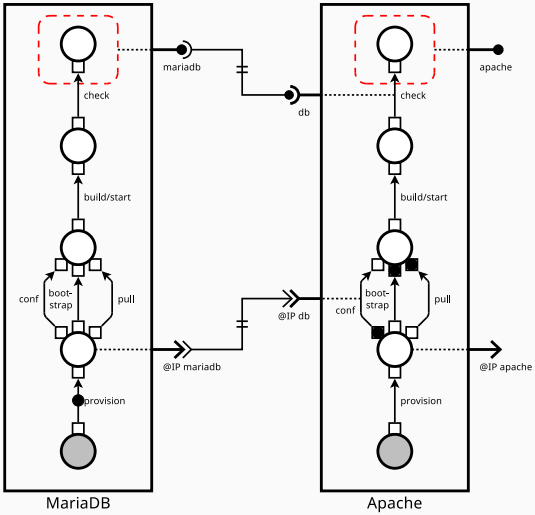

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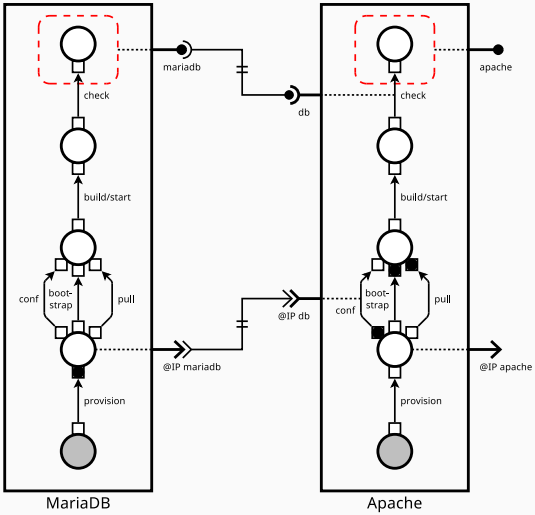

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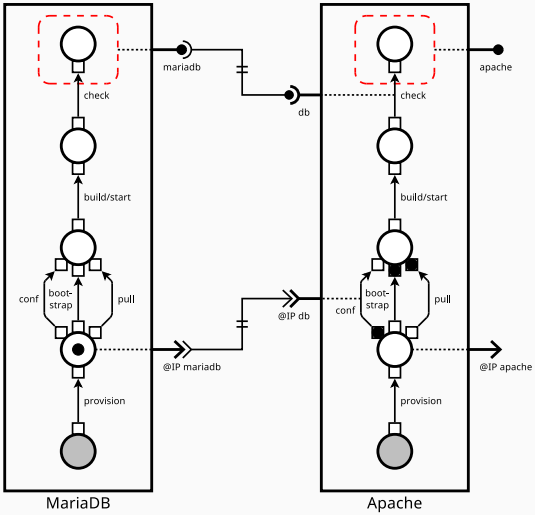

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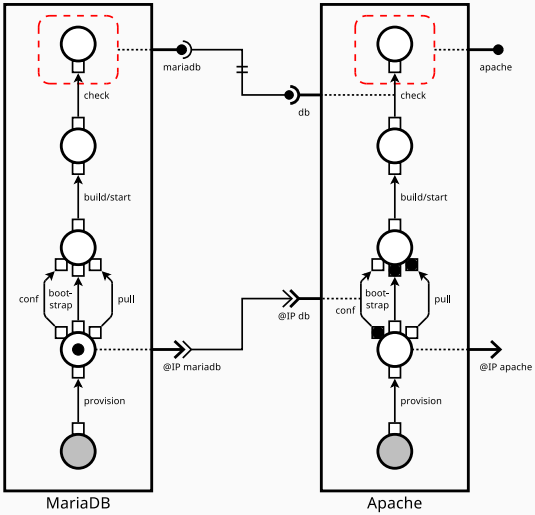

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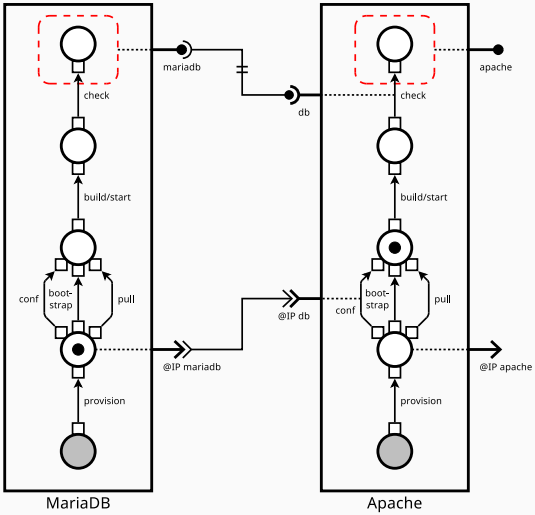

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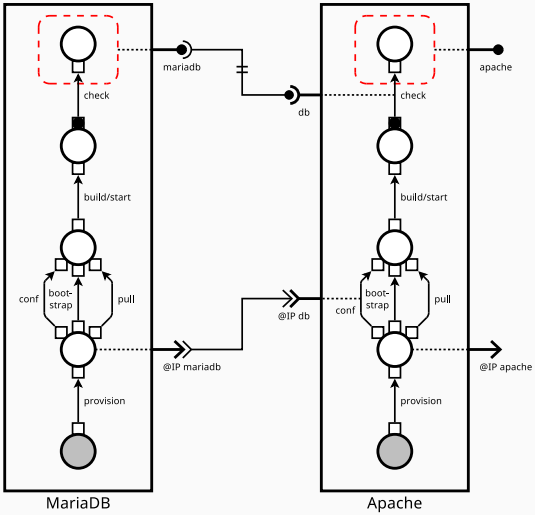

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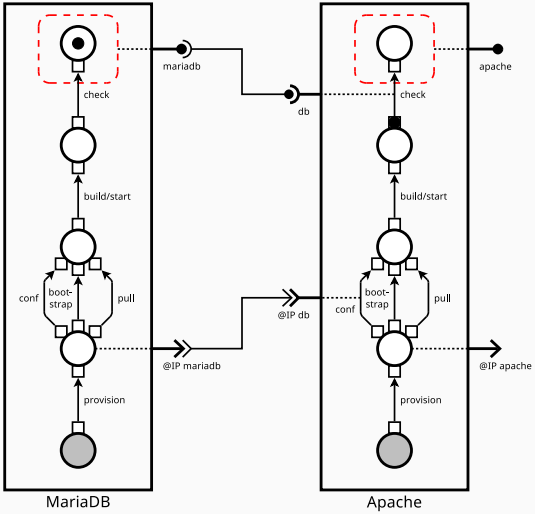

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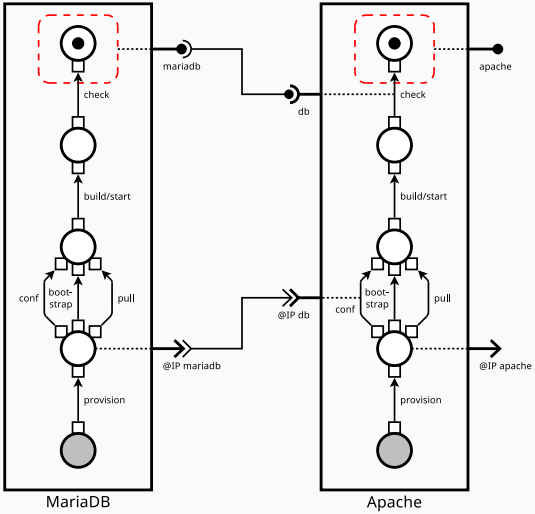
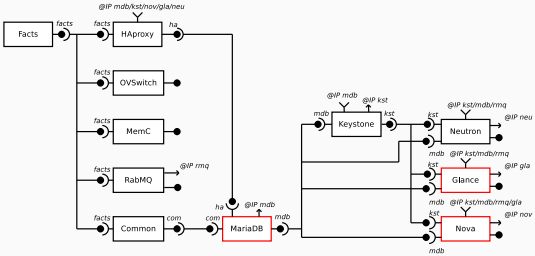


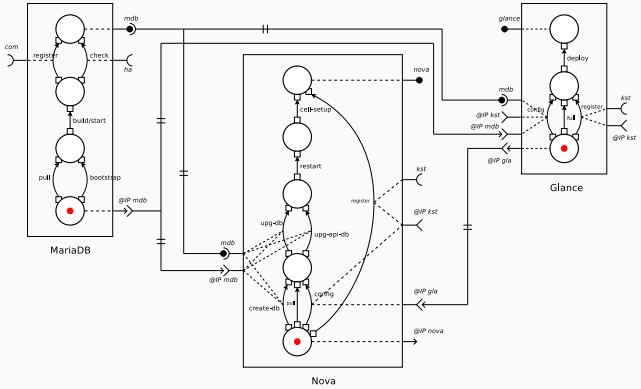
Experiments (1/4)

- "OpenStack is a cloud operating system that controls large pools of compute, storage, and networking resources throughout a datacenter"
- Kolla-ansible commissioning of OpenSatck (36 services gathered in 11 components, deployed on three nodes).



Experiments (2/4)

	Places	Trans.	Ports
Facts	2	1	1
Common	3	2	2
HaProxy	2	1	7
MemCached	2	1	2
MariaDB	4	5	4
RabbitMQ	2	1	3
Keystone	3	2	4
Glance	3	4	7
Nova	5	8	8
OpenVSwitch	3	1	2
Neutron	3	4	7
Total	32	30	47



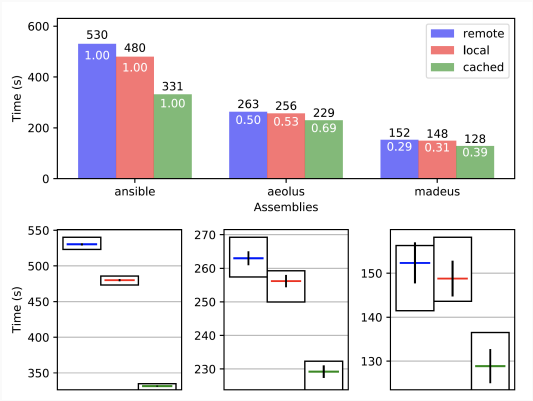
Experiments (3/4)

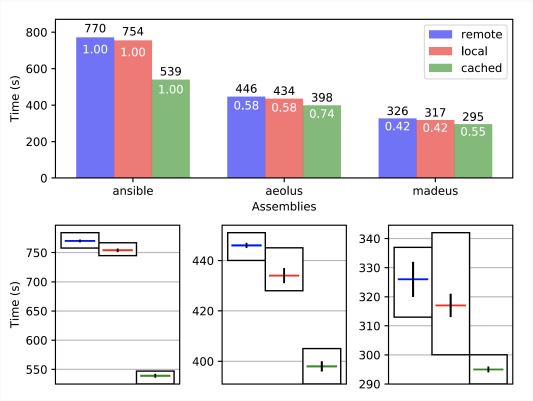
- Kolla-Ansible = Docker + Ansible

	Compute	Network	Control
# images	9	11	16
Total size (MB)	2767	2705	4916

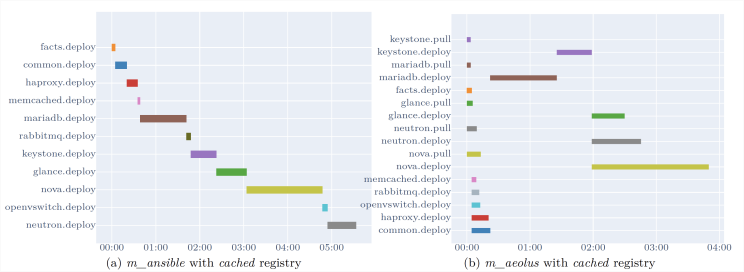
- 3 types of Docker registries: remote, local, cached
- benchmarks on two different clusters of Grid'5000: ecotype (Nantes), nova (Lyon)

results - performance (1/2)



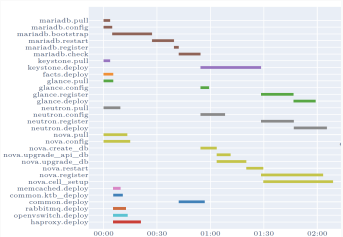


results - tasks analysis (2/2)



(a) *m_ansible* with *cached* registry

(b) *m_aeolus* with *cached* registry



(c) *madeus* with *cached* registry

Distributed software reconfiguration: Concerto

Why reconfiguration?

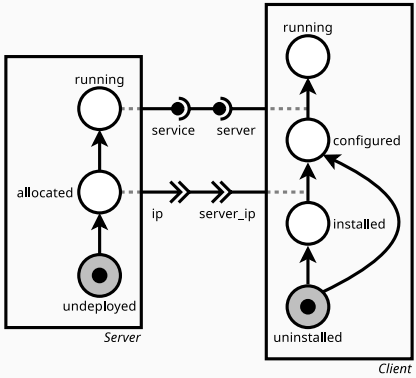
- Resources, placement and network changes
  - optimization
  - mobility
  - faults
- Software topology changes
  - optimization
  - energy, security, sensors etc.
  - external events
- Software update
- etc.

State of the Art

Autonomic reconfiguration: MAPE-K as a general model

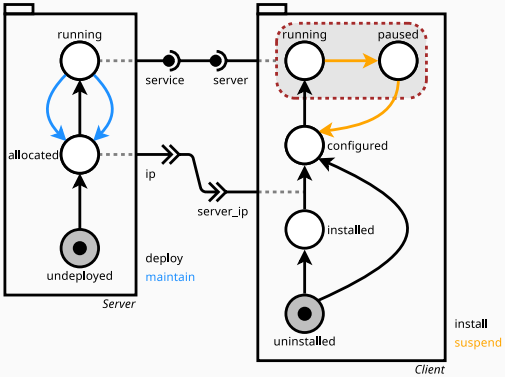
- (M) monitoring (monitor the software system and its environment)
- (A) analysze (choose a new configuration)
- (P) plan how to move to the new configuration
- (E) execute the plan
- (K) the set of models shared by MAPE
- State of the art mainly on (A) and (P)
  - considering simple (K) models for (E)
  - no parallelism, no distribution etc.
- We focus on building new (E) models
  - Aeolus is the closest in terms of modeling
  - Ansible is the better production tool for expressivity freedom (but hand-coded)

Concerto



Concerto = Madeus + Behaviors + ScoreL language

Concerto

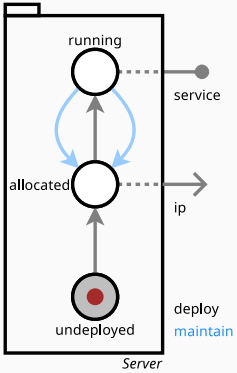


Concerto = Madeus + Behaviors + ScoreL language

Concerto - Deployment example

Example (Deployment)

```
add(s : Server)
add(c : Client)
con(s.ip, c.server_ip)
con(s.service, c.server)
pushB(s, deploy)
pushB(c, install)
wait(c)
```



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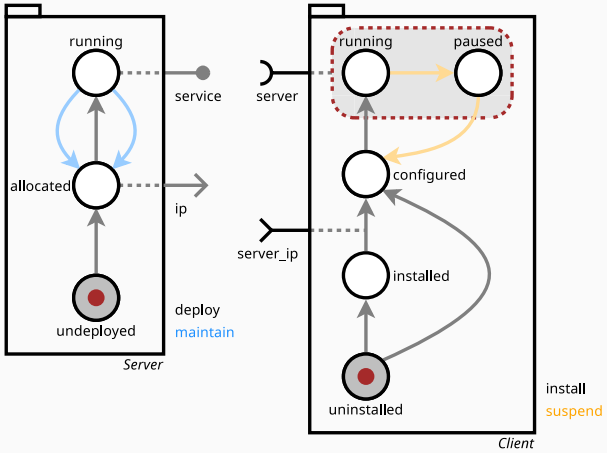

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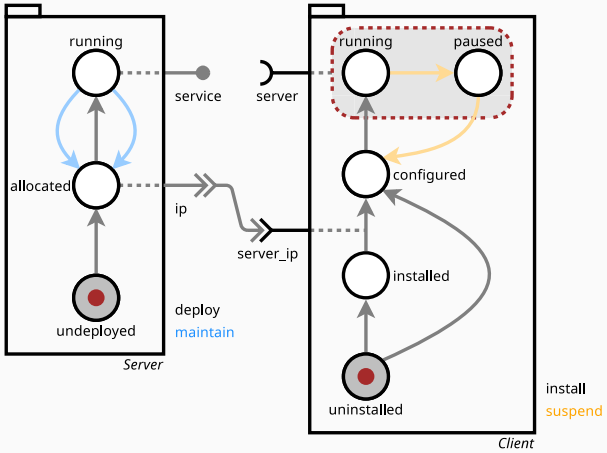

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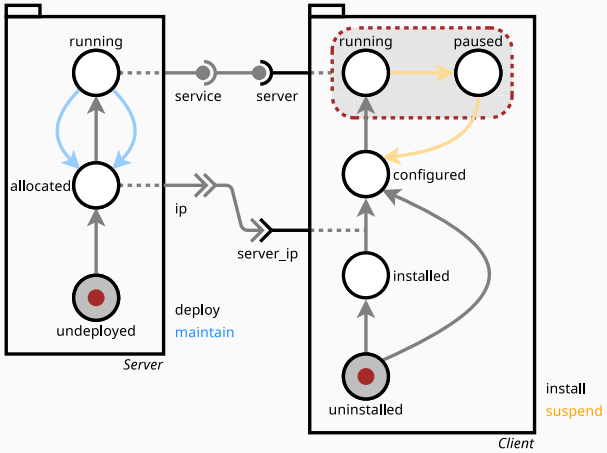

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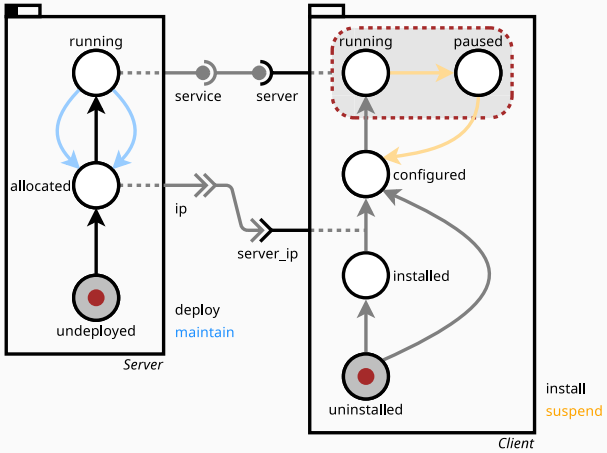

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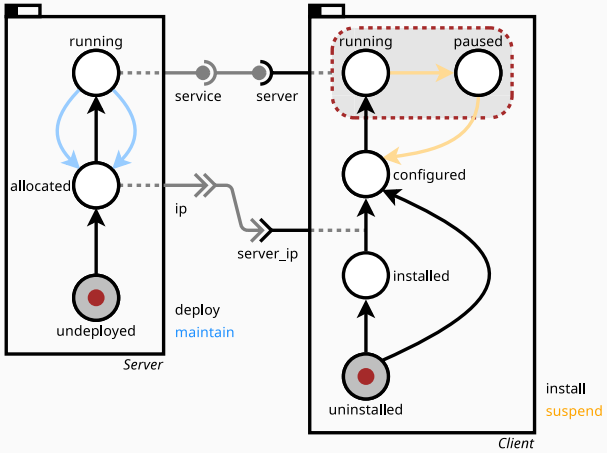

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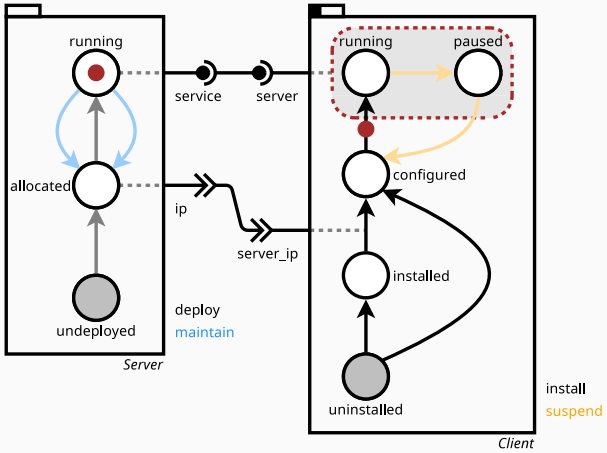

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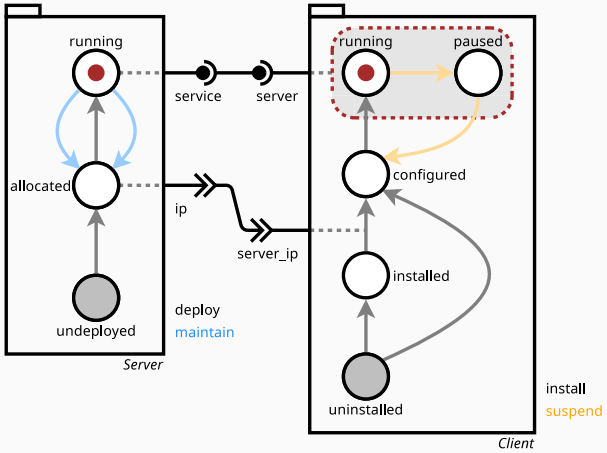

Concerto - Maintenance example

Example (Maintenance)

```
pushB(s, maintain)
pushB(s, deploy)
pushB(c, suspend)
wait(s)
pushB(c, install)
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```

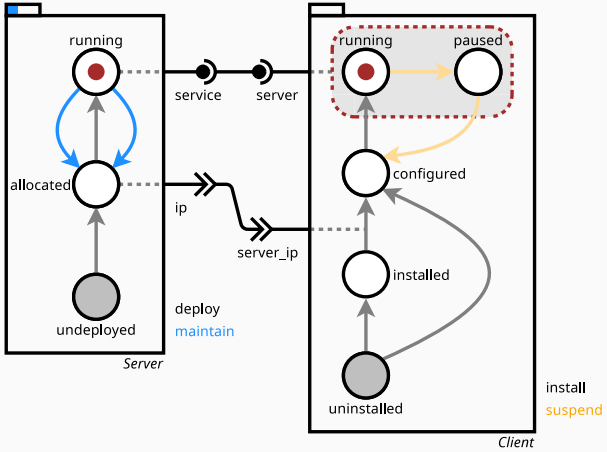

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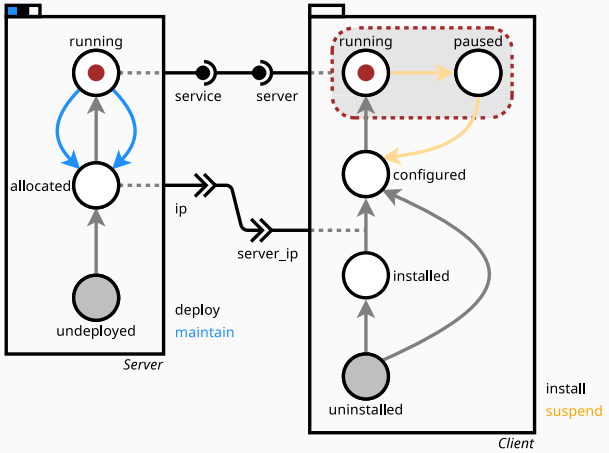

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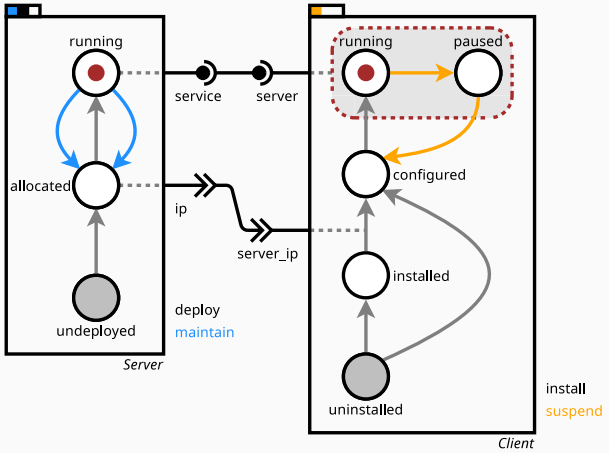

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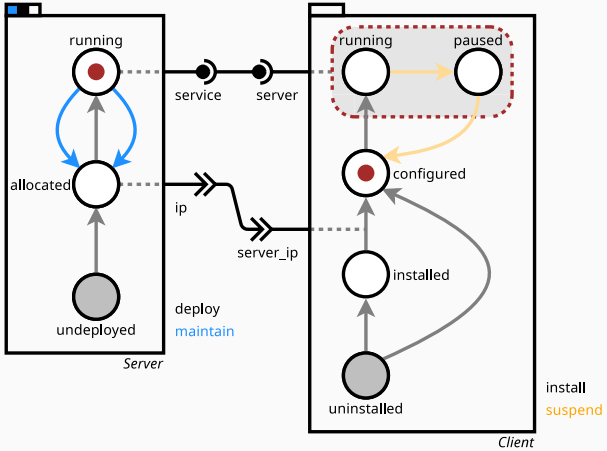

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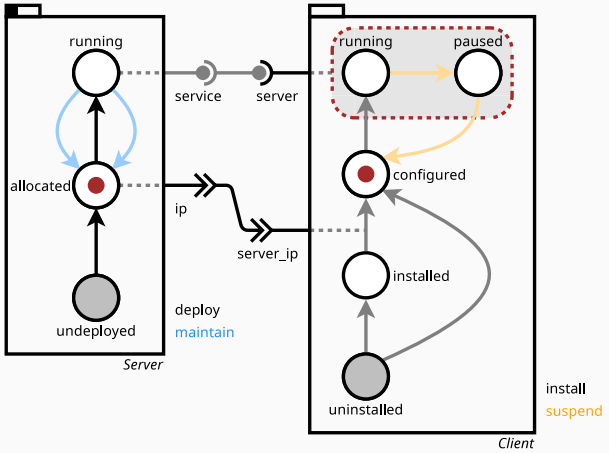
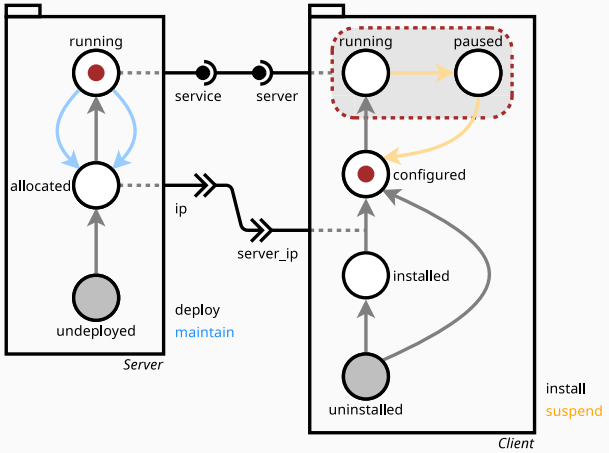


Concerto - Maintenance example

Example (Maintenance)

```
pushB(s, maintain)
pushB(s, deploy)
pushB(c, suspend)
wait(s)
pushB(c, install)
wait(c)
```



Concerto - Maintenance example

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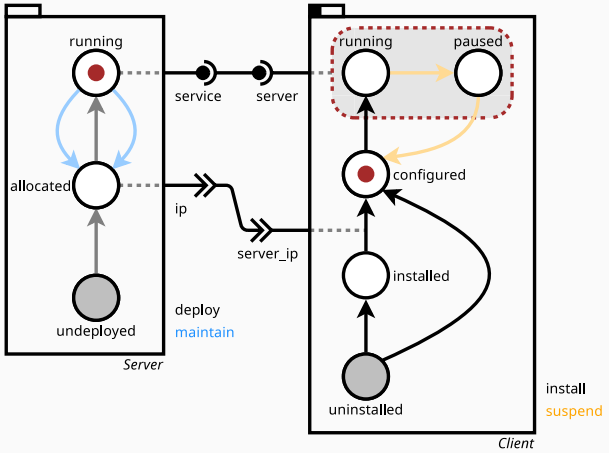

Concerto - Maintenance example

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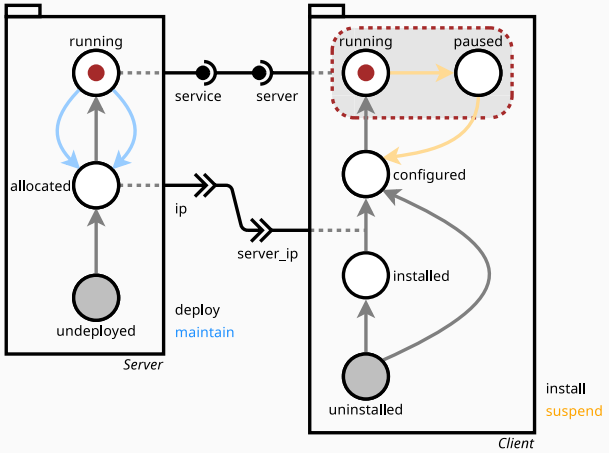


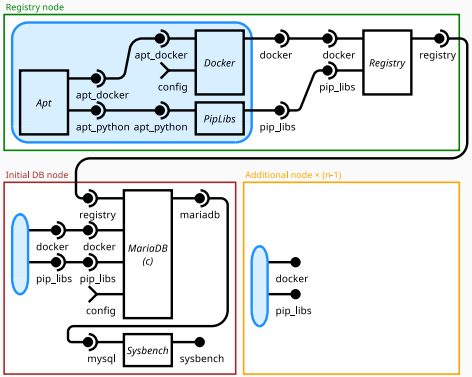
Experiments - decentralized DB (1/3)

Use-case

- From centralized MariaDB to decentralized MariaDB
- Galera cluster of MariaDBs (see the OpenStack summit)
- Reference code written with Ansible (see Juice)

Experiments - decentralized DB (2/3)

- Deployment: Docker registry, MariaDB
- Reconf1: Docker registry, 1 MariaDB master, 1 MariaDB worker
- Reconf2: Docker registry, 1 MariaDB master, N MariaDB worker



Experiments - decentralized DB (2/3)

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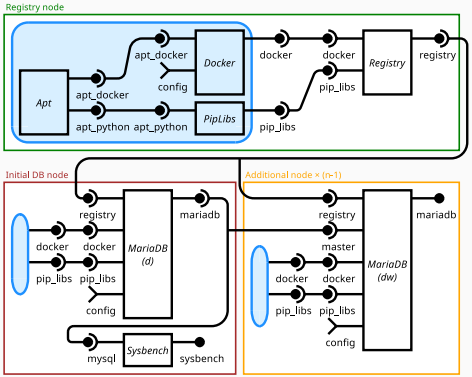

Experiments - decentralized DB (2/3)

- Deployment: Docker registry, MariaDB
- Reconf1: Docker registry, 1 MariaDB master, 1 MariaDB worker
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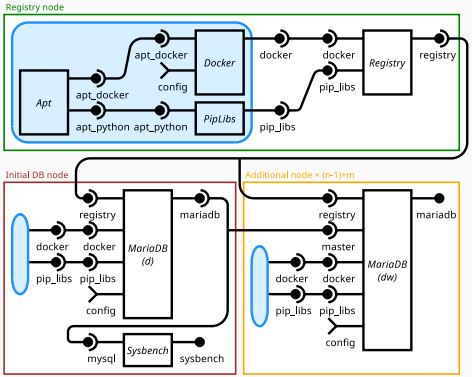
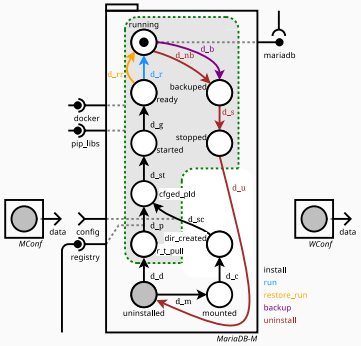


Experiments - decentralized DB (3/3)

Example (Deployment)

```
pushB (sysbenchm, suspend)
pushB (mariadb1, backup)
pushB (mariadb1, uninstall)
con (mconf.data, mariadb1.config)
for i in 2..n: [n+1..n+m]
  add (mariadb{i} : MariaDBw)
  con (wconf.data, mariadb{i}.config)
  con (mariadb1.mariadb, mariadb{i}.master)
  con (docker{i}.docker, mariadb{i}.docker)
  con (piplibs{i}.pip_libs,mariadb{i}.pip_libs)
  con (r_registry.registry,mariadb{i}.registry)
for i in 1..n:
  pushB (mariadb{i}, install)
pushB (mariadb1, restore_run)
pushB (sysbenchm, install)
```



Experiments - decentralized DB (3/3)

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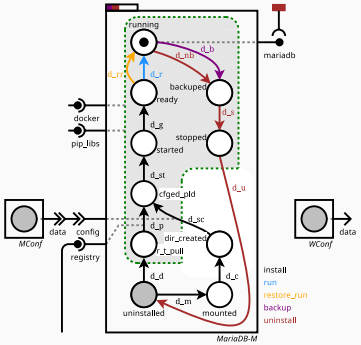

Experiments - decentralized DB (3/3)

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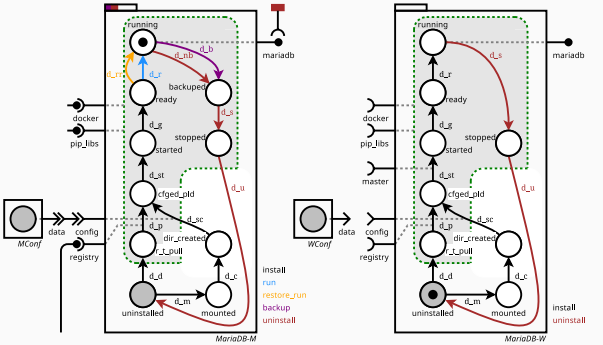

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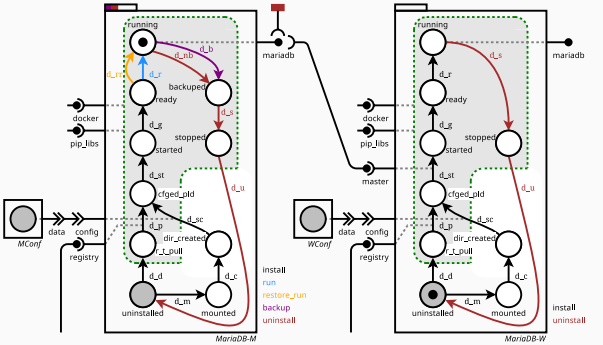

Experiments - decentralized DB (3/3)

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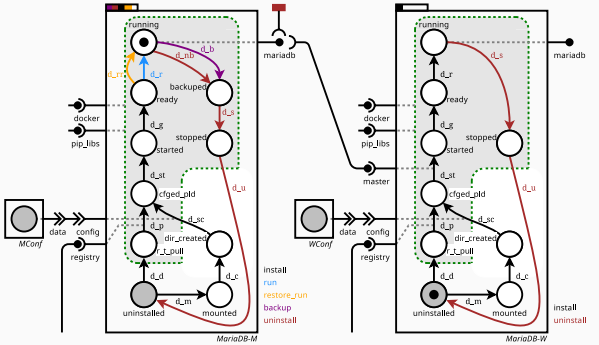


Safety

Why safety?

Getting guarantees on commissioning and reconfiguration

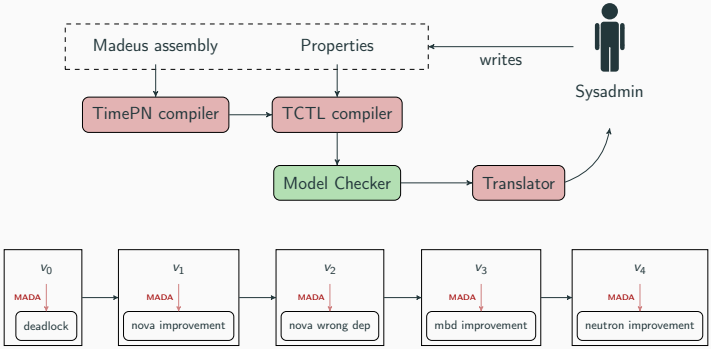
- attainability
- liveness
- invariants on the validity of the assembly
- performance analysis

Using formal methods as an helping tool to design safe and efficient procedures

- efficiency analysis
- fault injections
- uncertainty

MADA - Overview

Study the use of model checking to help in the design of safe and efficient distributed software commissioning



MADA - Properties

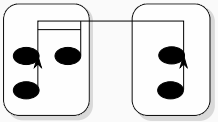
- Time Petri nets are used
  - intervals of time given for each transition representing a Madeus transition

```
def set_interval(self, component, transition, min, max)
def add_deployment(self, name, dict_componentsplaces)
```

- High Abstraction Level Properties (HALP)
  - qualitative properties
  - quantitative properties

```
def deployability(self, deployment_name, with_intervals)
def sequentiality(self, ordered_list_components_transition)
def forbidden(self, list_marked, list_unmarked)
def parallelism(self, full_assembly, list_components)
def gantt_boundaries(self, deployment_name, mini, maxi, critical)
```

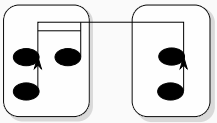
VeRDi - Project



Verified Reconfiguration Driven by execution

- Charlène Servantie - Engineer for 18 months
- Dimitri Pertin - Engineer for 2 months
- Simon Robillard - Postdoc for 18 months

VeRDi - On going work



Verified Reconfiguration Driven by execution

- model checking approach for Concerto (such as MADA)
- compositional verification of Concerto programs
- synthesis of reconfiguration scripts in Concerto

Perspectives

Perspectives

Perspectives for autonomous reconfiguration

- decentralized reconfiguration
- online (A) and (P) decisions

Perspectives for safety

- handling errors in reconfiguration
- handling uncertainty in reconfiguration
- more complex control loop including formal verifications

Perspectives

Collaboration on the DAO project?

- Madeus and Concerto offer safe and efficient coordination for reconfiguration
- could be extended to Cyber-physical systems reconfiguration

Thank you

Thank you !

Questions?