Zephyrus2: On the Fly Deployment Optimization using SMT and CP Technologies

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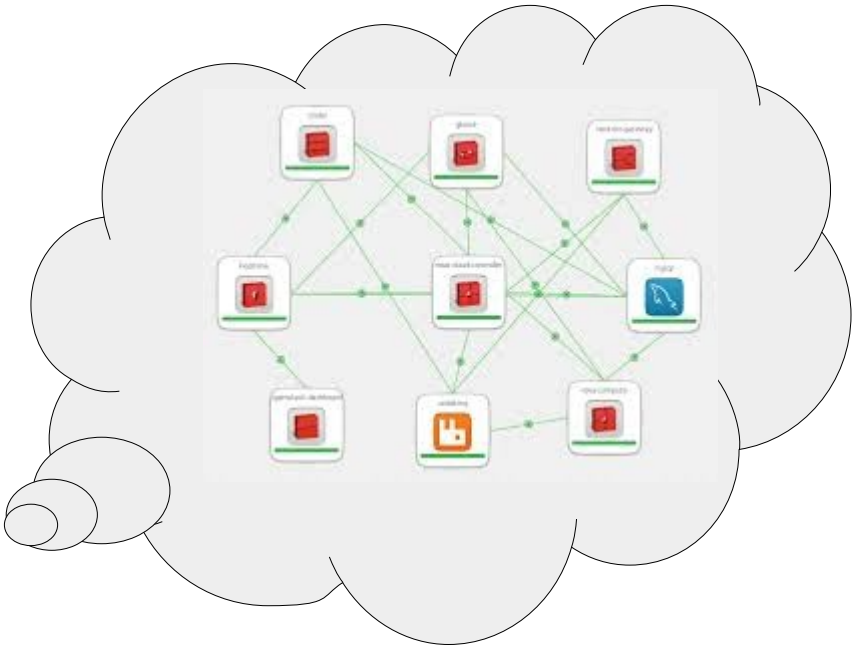
Motivation

Automatize deployment

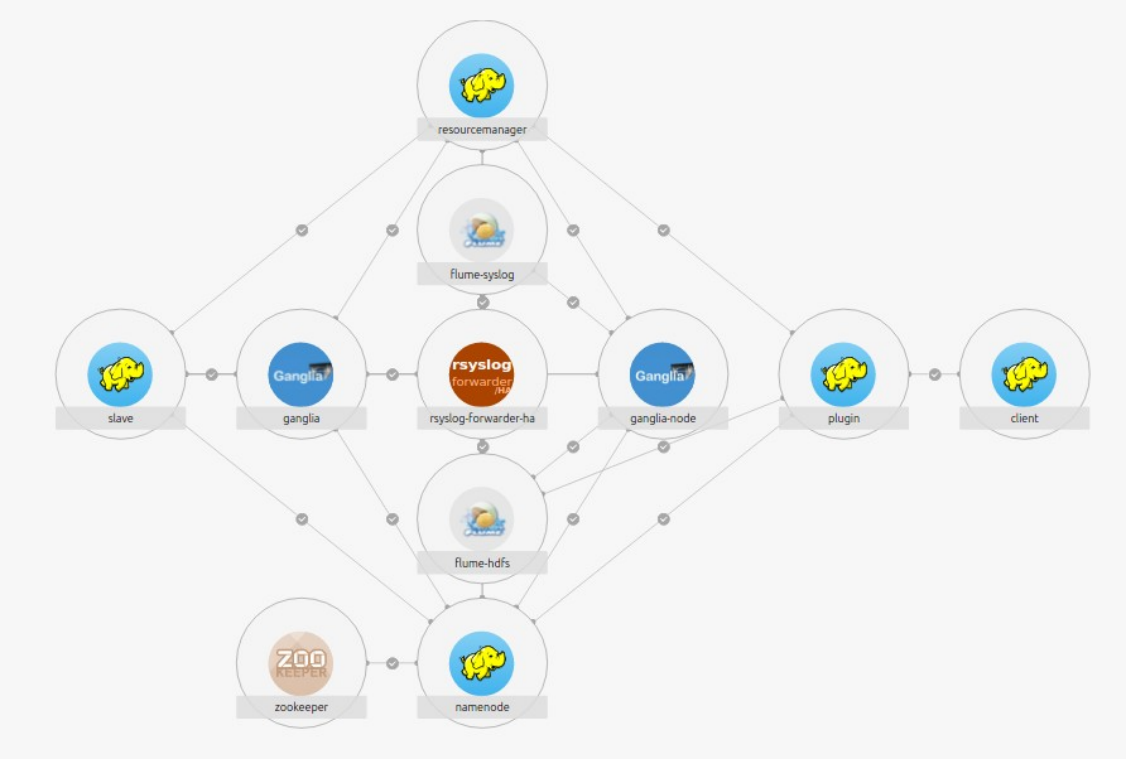


The dream

Automatize deployment

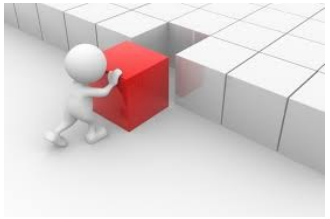
From Configuration to Deployment

TOSCA, JUJU (Canonical), Kubernetes, …



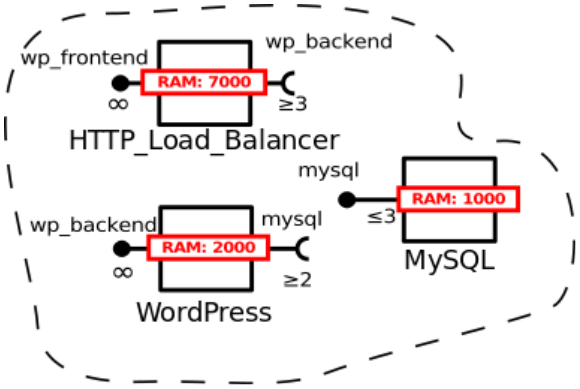
Challenges

- Cloud provides computational resources but
  - Which ones are best for us? E.g., amazon c4-xlarge or c4-2xlarge?
  - What components should be deployed and where?
  - How to connect the components?
- Zephyrus2 → Tool that helps in finding optimal configuration exploiting (cloud) computing resources



Zephyrus2

Deployable Components

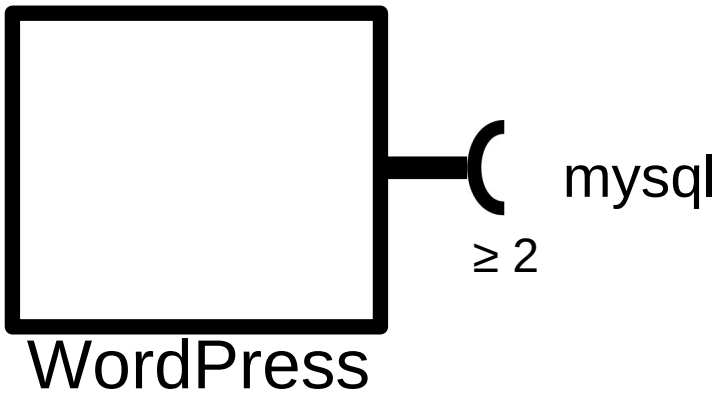


Universe of Components

Box with a name

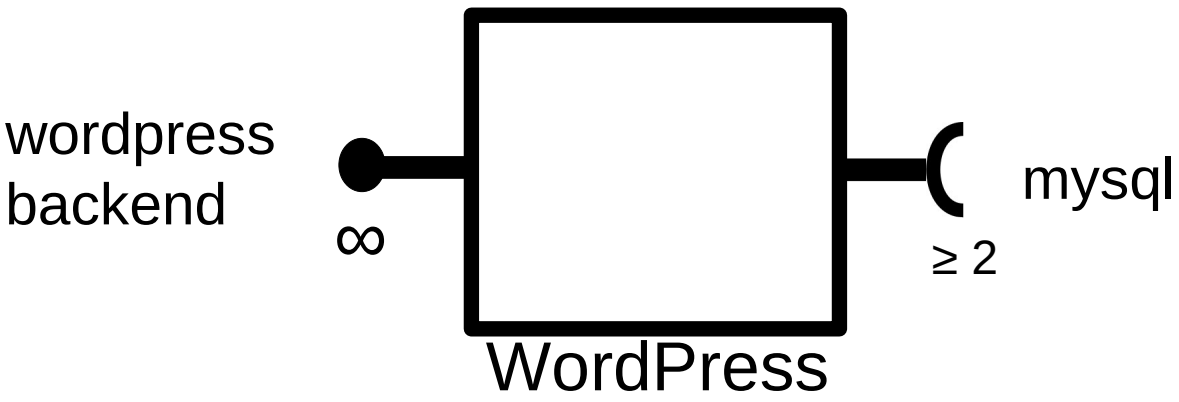
Universe of Components

Requirements



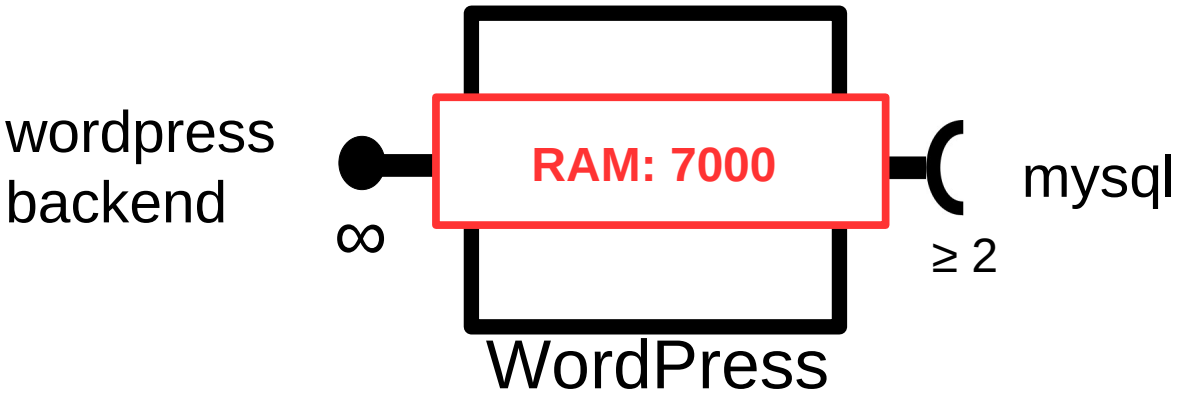
Universe of Components

Functionalities offered

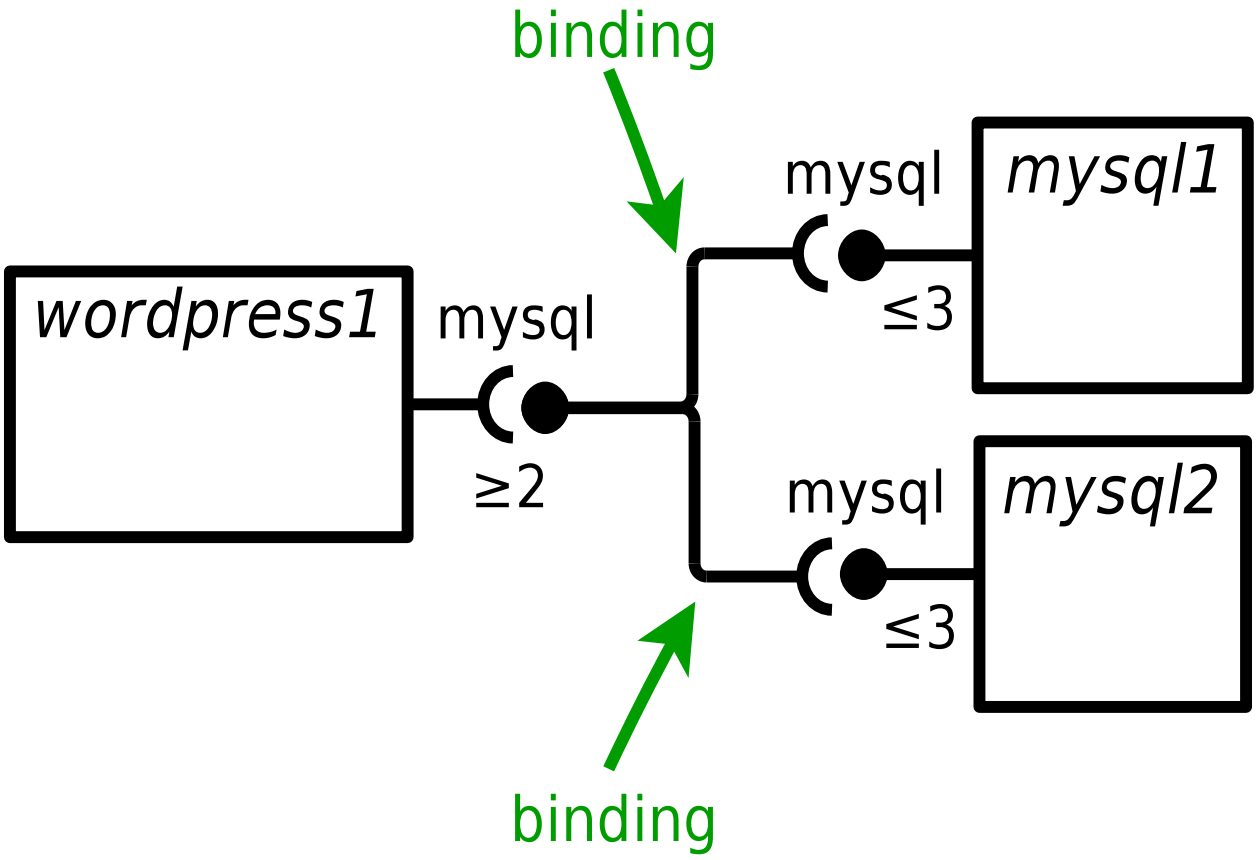


Universe of Components

Resource consumption

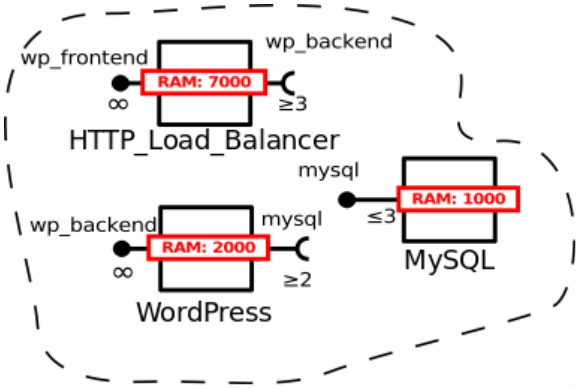


Bindings

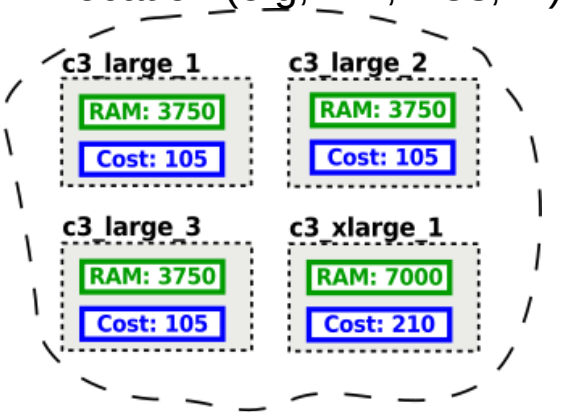

binding
mysql
mysql1
wordpress1
mysql
≤3
≥2
mysql
mysql2
≤3
binding

Zephyrus2

Deployable Components

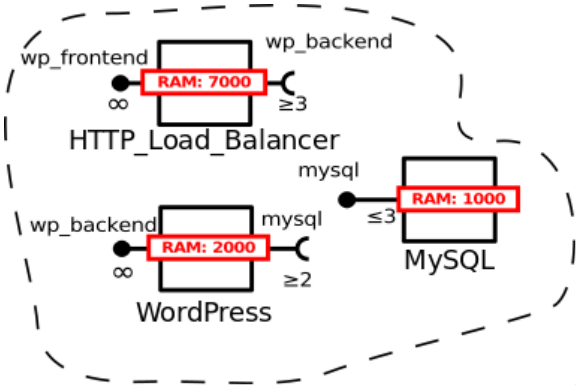


Location (e.g, VM, PCs, ...)



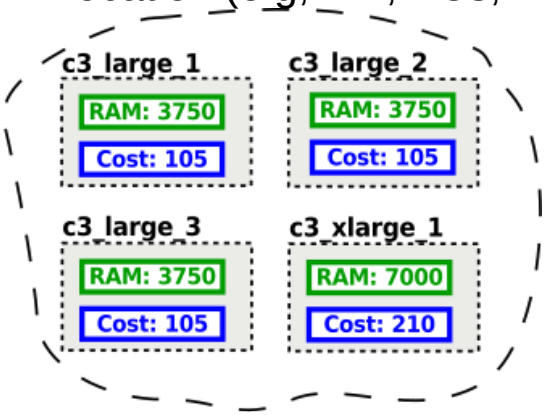
Zephyrus2

Deployable Components



User Desiderata

Location (e.g, VM, PCs, ...)

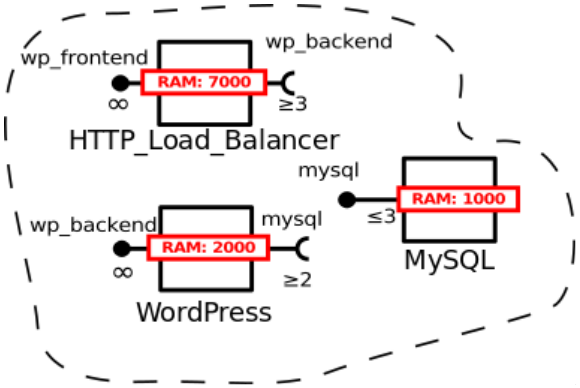


Specification : declarative

- Constraints describing VM (locations) & components
- Components in VM:
  - HTTP_Load_Balancer > 0 and c3_large[1].WordPress = 1
- Co-location:
  - forall ?x in locations: (?x.WordPress > 0 impl ?x.MySQL > 0)
- Distribution:
  - forall ?x in locations: (?x.HTTP_Load_Balancer > 0 impl
    (sum ?y in components: ?x.?y) = 1)
  - forall ?x in locations: (?x.MySQL < 2)

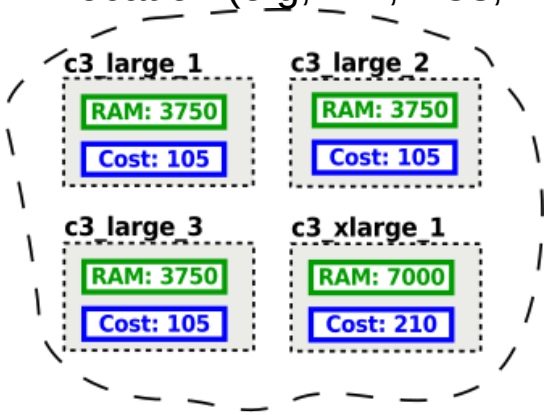
Zephyrus2

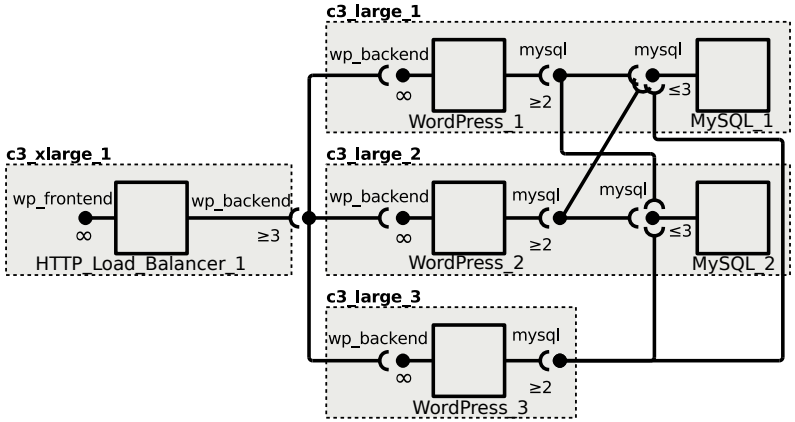
Deployable Components



User Desiderata

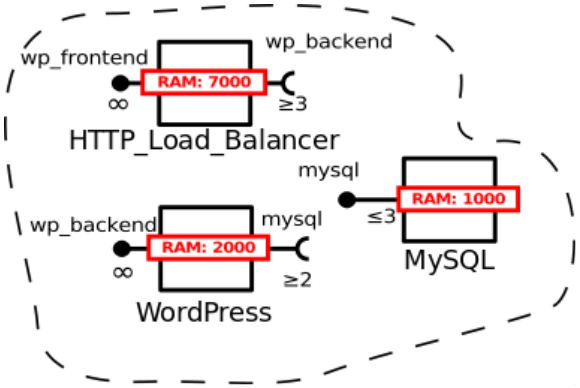
Location (e.g, VM, PCs, ...)





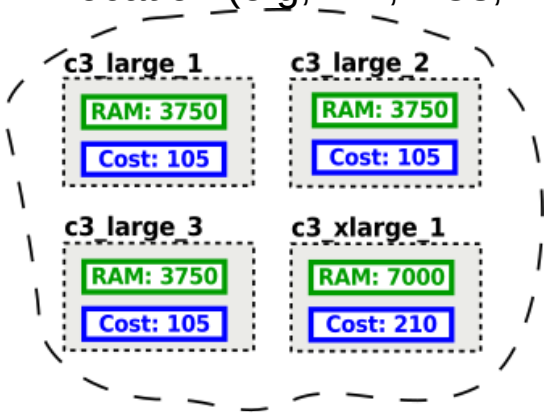
Zephyrus2

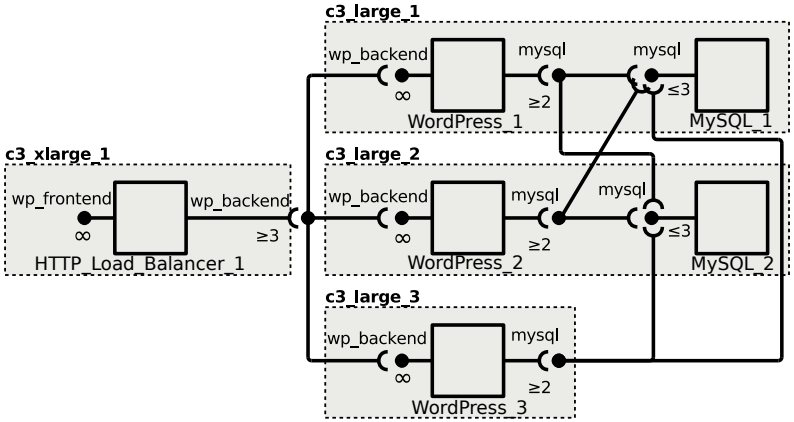
Deployable Components



User Desiderata

Location (e.g, VM, PCs, ...)





Optimization Criteria:

- less expensive,

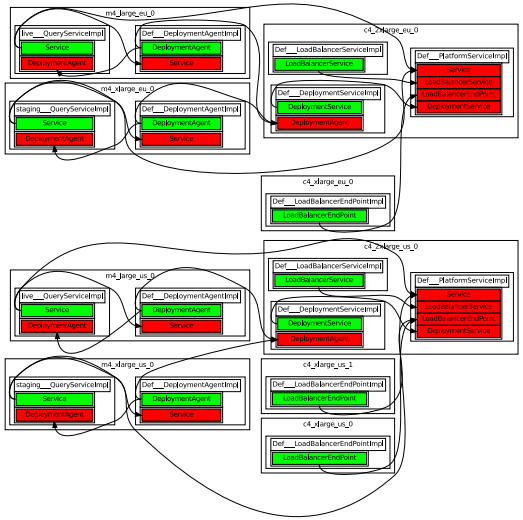
…

Internals

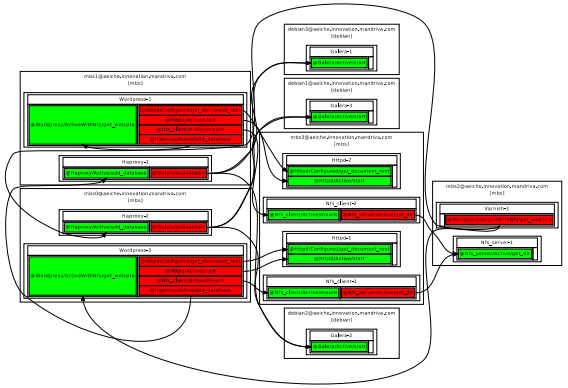
- Problem encoded into Constraint Optimization Problems
  - MiniZinc language → Use of state of the art constraint solvers
  - SMT solver → Z3 with new optimization function
- Open source:
  - https://bitbucket.org/jacopomauro/zephyrus2
- Deployable via Docker + Input and output in JSON

Complex industrial examples

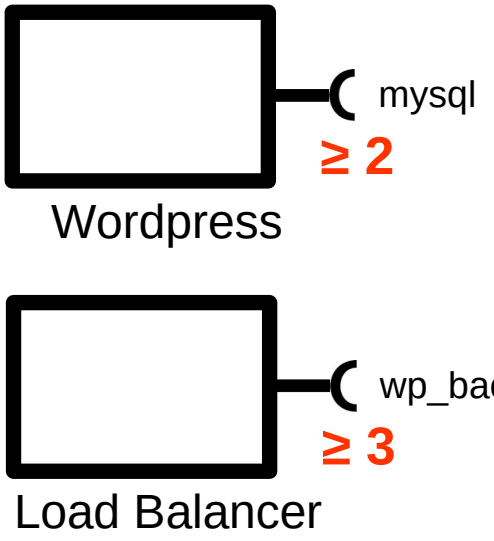
SDL

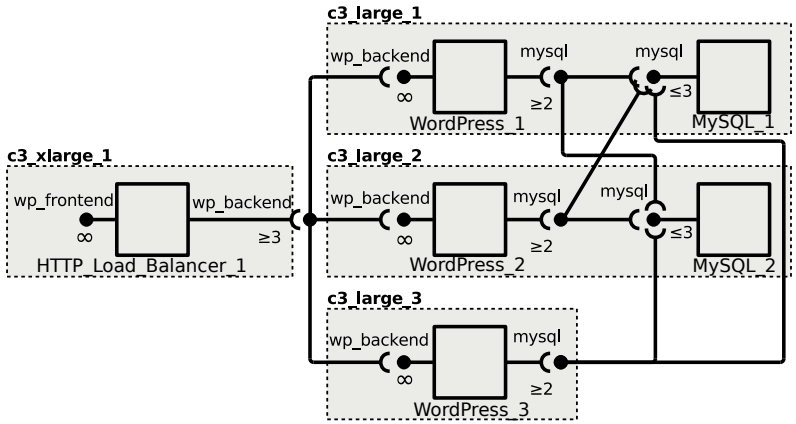


Mandriva



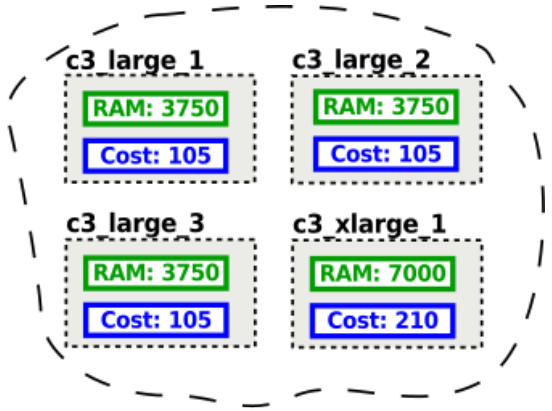
Experiments - Benchmarks





Parameters

- mysql_req: 6 … 12
- wp_req: 6 … 12
- vm_amount: 6 … 25

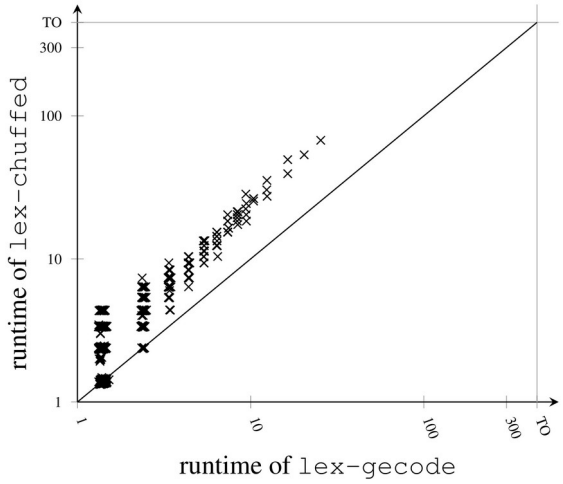


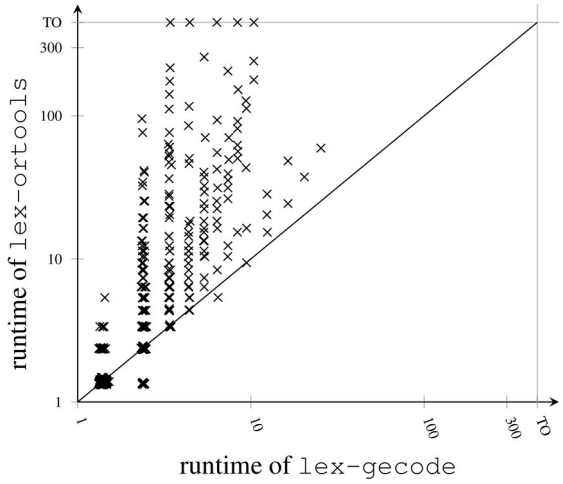
Experiments - Overview

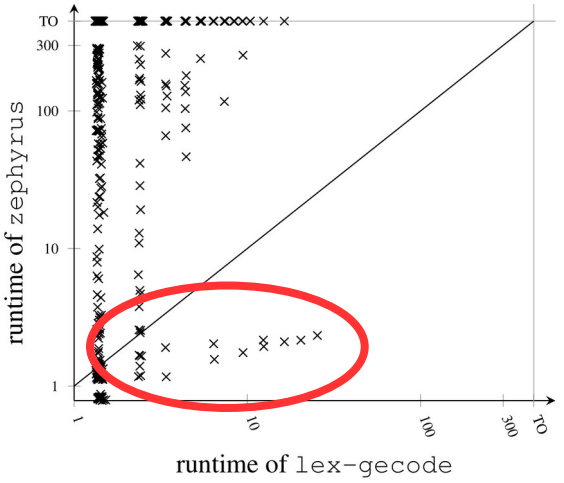
Solver	Solved	Timeout	Seconds
zephyrus	261 (27%)	719	67.81
chuffed	980 (100%)	0	4.45
Gecode	**980 (100%)**	**0**	**2.25**
OR-Tools	975 (99%)	5	7.13
Z3 (SMT)	960 (98%)	20	50.23

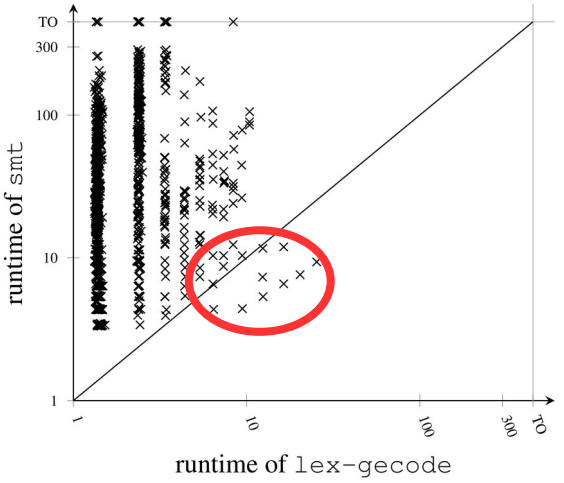
linearized, with redundant constraints, with symmetry breaking constraints

Experiments - Details









Experiments – Different Encodings

- Redundant constraints
  - Very beneficial for OR-Tools and Gecode
  - Irrelevant for chuffed and Z3
- Symmetry breaking
  - Beneficial for all solvers
  - Without: Z3 > OR-Tools > chuffed / Gecode

Z3 / SMT:

Robust, reasonably fast on suboptimal encoding

chuffed / Gecode:

Very efficient on properly encoded problems

Conclusions & Future Work

- Zepyrus2: state of the art configurator
  - Produce configuration with hundreds of components/virtual machines
  - Easily usable and deployable
- Future:
  - Better SMT encoding
  - Use portfolio techniques
  - Richer model support for components
  - More benchmarks