Parametric, Probabilistic, Timed Resource Discovery System

2nd SynCoP Workshop

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Roadmap

1. Problem
   - Real-life problem
   - Reservation protocol
2. Modeling the system
   - Modeling each machine
   - Modeling the reservation system
   - Interactions between automata
3. Verification of the system
   - Parameters of the system
   - Expected behavior
4. Conclusion

Real-life problem

Problem: **share resources**

- For example: computing nodes in a lab
- Exclusive access
- Fair resource sharing

Resource assignment systems

- Reservation systems, batch schedulers: OAR, PBS, Torque, SLURM...
- Use a front-end node: centralized, requires a dedicated node, need to connect to the front-end to access the resources $\rightarrow$ overhead

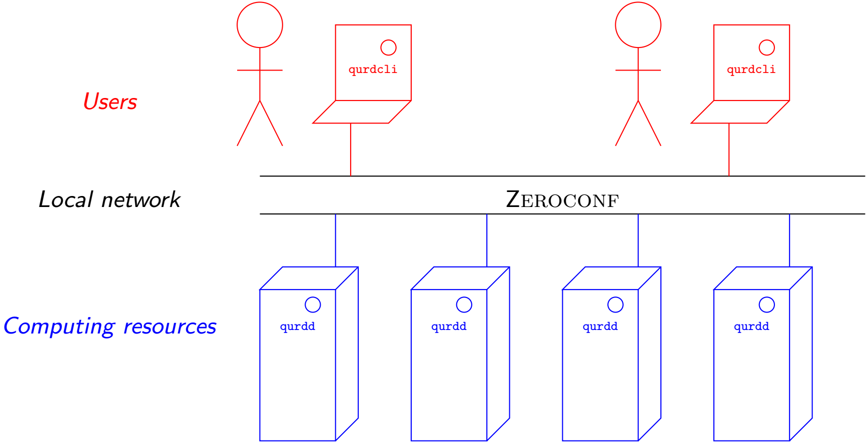
In small organizations (one lab, a set of servers...), might not be possible

$\rightarrow$ **Fully distributed** resource discovery and reservation system: QURD.

Architecture

QURD is *completely distributed*:

- No additional node
- Runs entirely on the computing resources and the clients



Zeroconf

Network protocol

- Originally: self-configuration of network devices
- Extended to other services: DNS, printers...
- Uses UDP multicast datagrams

Operations available:

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- *Advertise*: also used for service detection, services advertise themselves on the network
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  - Client: listens to the network and reads the datagrams
- *Resolution*: typically used by mDNS
  - Client: multicast datagram "what is the IP address associated with this name?"
  - Host that has this name: "I am this machine, here is my IP address"

Reservation protocol

Advertise on Zeroconf

- Available machines *publish* themselves on the Zeroconf bus
- When machines are reserved, they *unpublish* themselves

Clients look at **which machines** are available on the network

- Once it has enough machines, it starts its application
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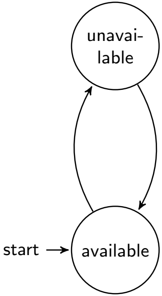
State of a machine

- *Available*: can be used
- *Reserved*, *running*, *finished*: cannot be used, already taken

Modeling each machine



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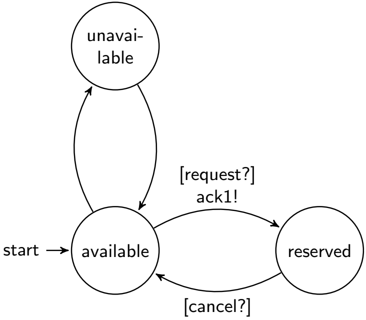

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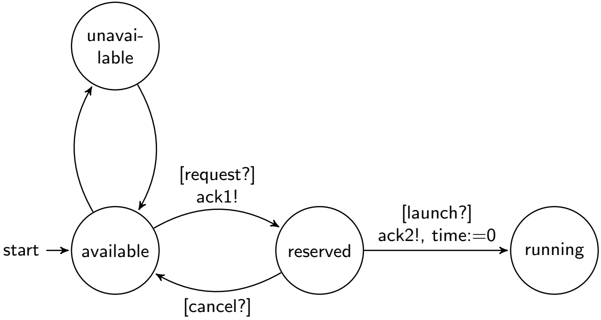

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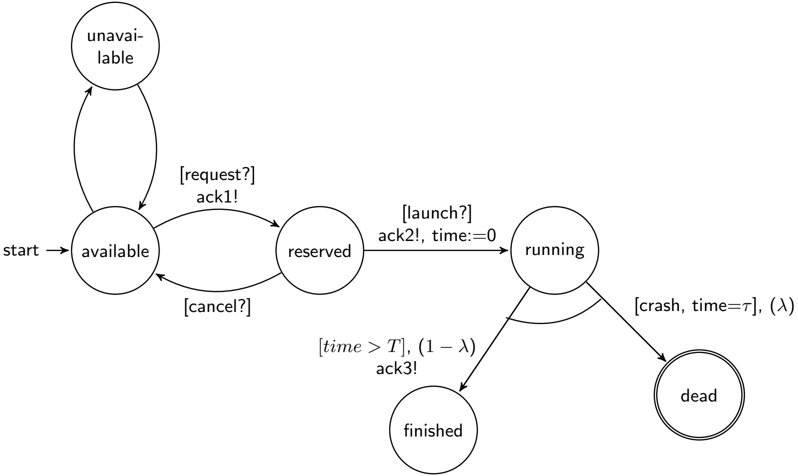

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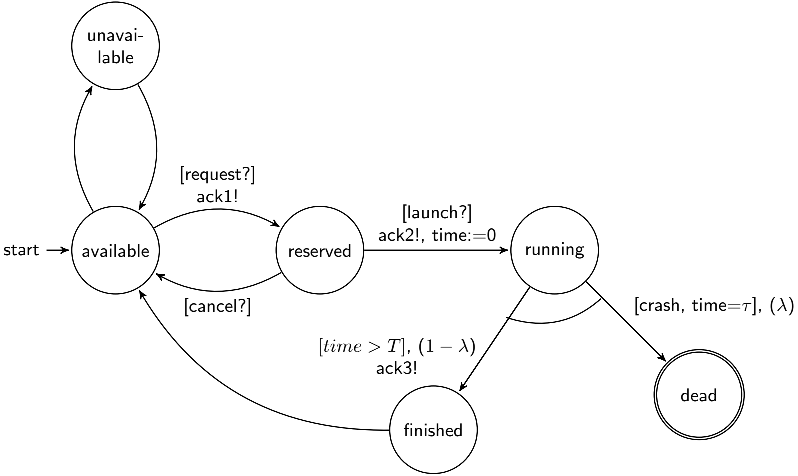
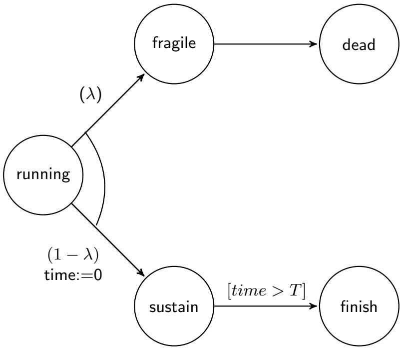


Resource volatility

Resources can fail while running a process

- Failure probability



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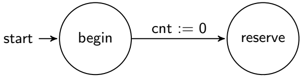

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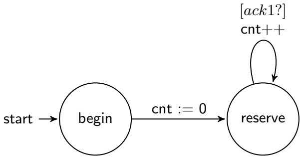

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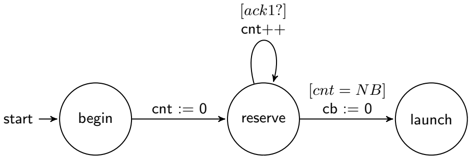

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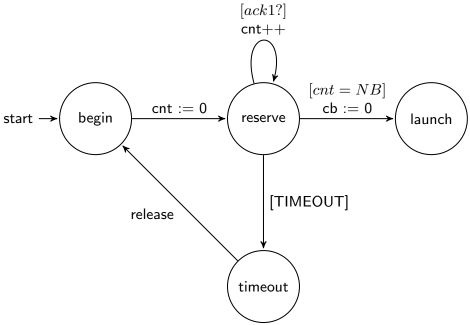

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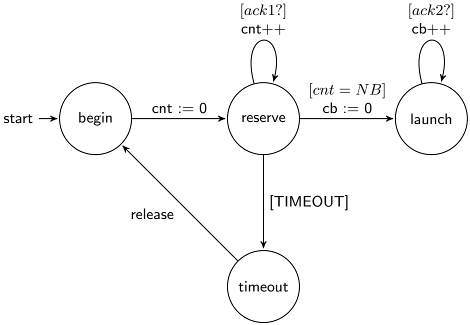

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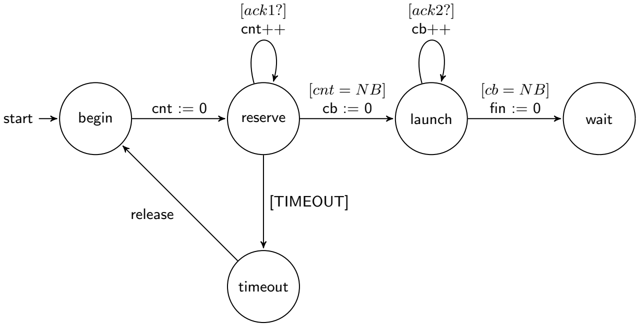

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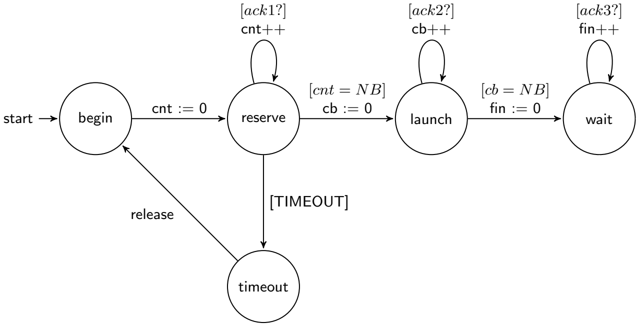

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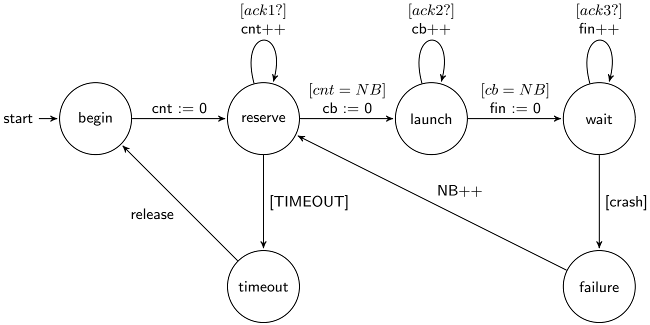

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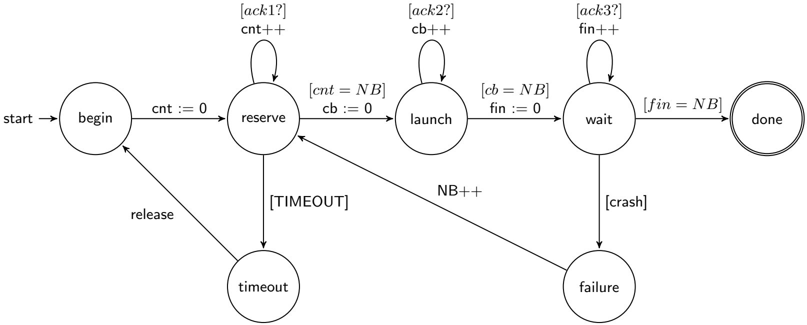
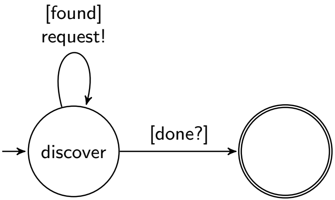


Close-up on the *reserve* state



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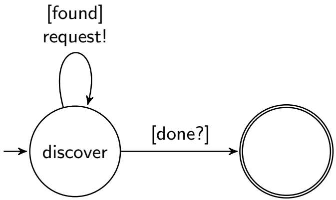

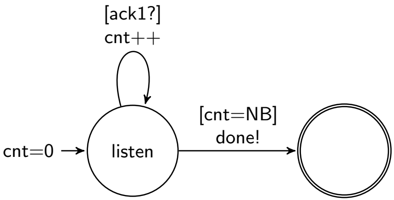

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- **Notify done** : once the local process of a resource is done running, the resource notifies the client → `ack3` action

Parameters of the system

Structural parameters

- Number of (concurrent) clients
- Number of resources

Application parameters

- Number of resources used by each job
- Execution time of each process (possibly unbalanced)
- Timeout (*wait* semantics), delay before retry (*fail* semantics)

Reliability parameter

- Failure probability

Expected behavior

Soundness :

- Option to complete, proper completion and no dead transitions
- Already verified with Petri nets

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  - Likelihood to complete before a deadline: "There is a likelihood of 50% that all the applications will be done after N time units, 25% after $2N$ time units, 15% after $3N$ time units and 10% that machines will crash too often for the applications to complete".

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- **System dimensioning**
  - Resource sizing: "How many machines do I need to be able to run that many jobs and be sure they will complete before that many time units"

Conclusion

Use-case: **distributed application**

- The **correctness** of the algorithm can be verified

Parametric

- Analyze the behavior of the system
- Leave some parameters unknown to dimension the system

Probabilistic

- Volatile environment: failure probability
- Also a parameter!

Challenging problem

- Large number of parameters
- Time, probabilities
- Potentially big automaton, made of several subparts replicated

→ Large state space