Simulating Autonomous Mobile Programs on Networks

Natalia Chechina

Dependable System Group,
Heriot-Watt University

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Aim of Research

- Obtain Detailed map of AMP behaviour;
- Estimate AMP capabilities;
- Investigate AMP behaviour on Wide Area Networks.

Load Balancing

- (in our case) Load balancing is a technique for work distribution between computers of the network.
- Main goals:
  - Minimizing execution time;
  - Maximizing resource utilization.

Taxonomy of Load Balancing Methods

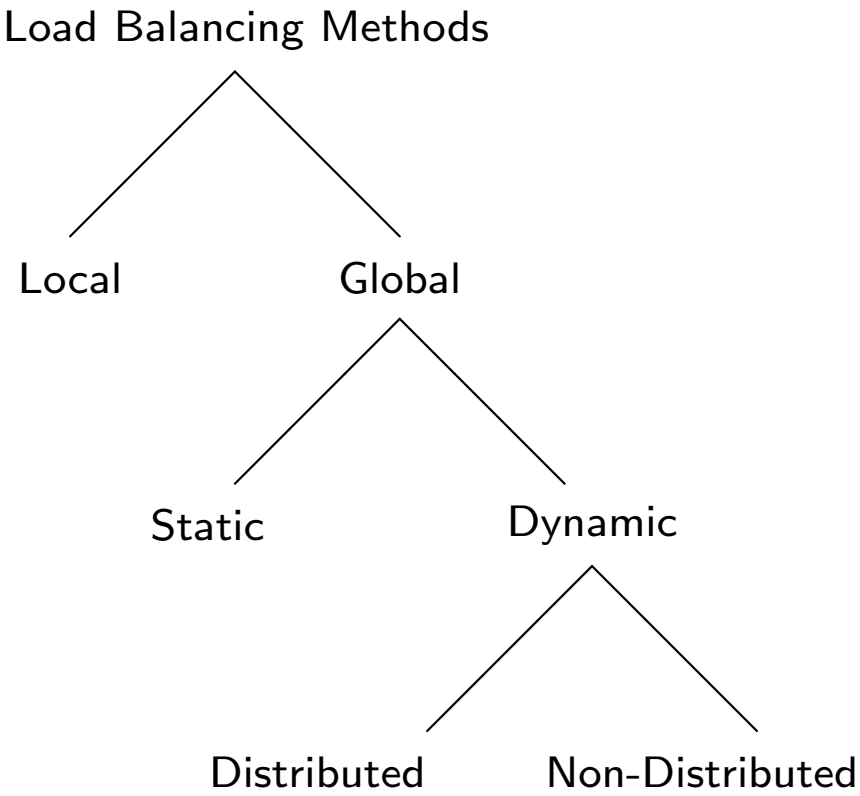

Figure: General [CK88]

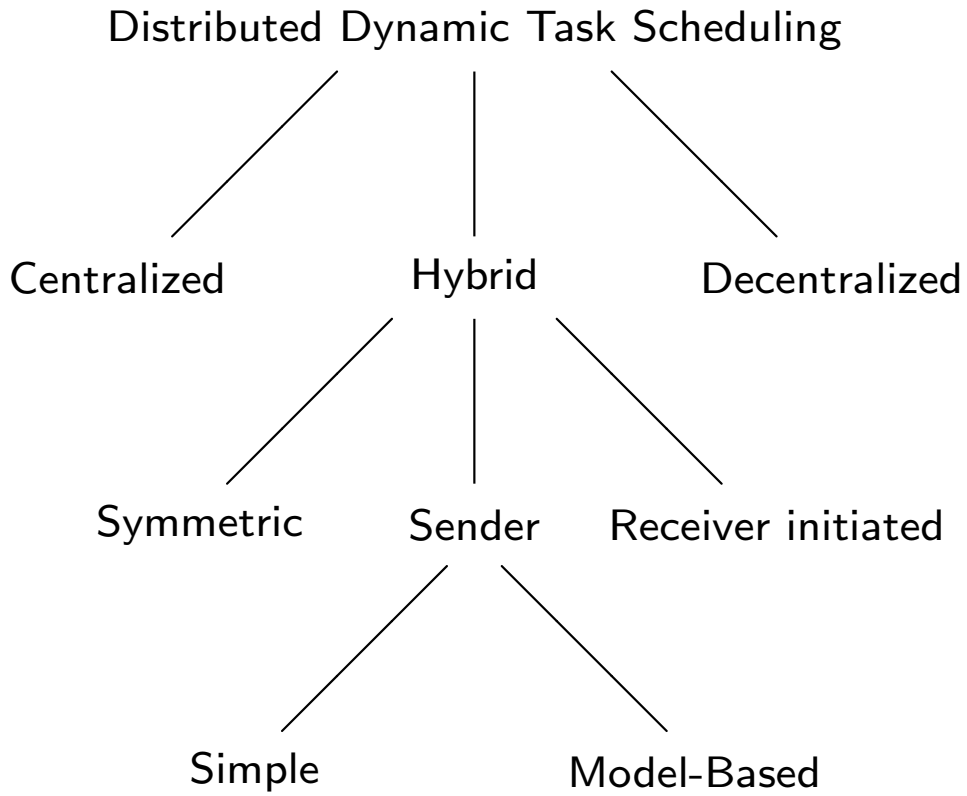

Figure: Dynamic Scheduling [Rot94]

Autonomous Mobile Program (AMP)

- The motivation for AMPs is to minimise processing time by seeking the most favourable resource, without any requirement to visit specific processor [Den07].
- AMPs periodically use a cost model to decide where to execute in the network.
- To reduce time for information exchanging, AMPs use load server architecture.

A Cost Model for AMP

$$T_{total} = T_{Comp} + T_{Coord} + T_{Comm} \quad (1)$$

$$T_h > T_{comm} + T_n \quad (2)$$

$$gran > \frac{T_{coord} \cdot S_h}{O} \quad (3)$$

T_{total} - total execution time;
T_{Comp} - time for computation;
T_{Coord} - total time for coordination;
T_{Comm} - total time for communication;
T_h - execution time on the current location;
T_n - execution time on new location;
$gran$ - part of work that must be executed between searches of better location;
O - overhead.

Simulation Model

- The simulation network is a fully connected graph of locations;
- At initial time all AMPs start on the first location;
- Program of square matrix multiplication of 1000 dimension is used in the experiments;
- The model is implemented on the OMNeT++ network simulator.

Homogeneous Network

- Type of experiments:
  - Optimal balance;
  - Near-optimal balance;
  - Adding more AMPs;
  - Removing AMPs.
- Number of locations: 3-5
- Number of AMPs: 5-13
- Speed of processors is 3139 MHz.

Optimal Balance

	5 AMPs	7 AMPs	9 AMPs	10 AMPs	13 AMPs
3 Locations					
real	1/2/2	1/3/3	1/4/4	-	-
simulation	1/2/2	1/3/3	2/3/4	-	-
4 Locations					
real	-	1/2/2/2	-	1/3/3/3	1/4/4/4
simulation	-	1/2/2/2	-	1/3/3/3	2/4/4/3
5 Locations					
real	-	-	1/2/2/2/2	-	-
simulation	-	-	1/2/2/2/2	-	-

Table: Optimal Balance

Near-Optimal Balance

	6 AMPs	5 AMPs
3 Locations		
real	1/2/3	-
simulation	1/2/3	-
2 Locs		
real	-	2/3
simulation	-	2/3

Table: Near-Optimal Balance [Den07, Figures 5.56, 5.57]

Adding More AMPs

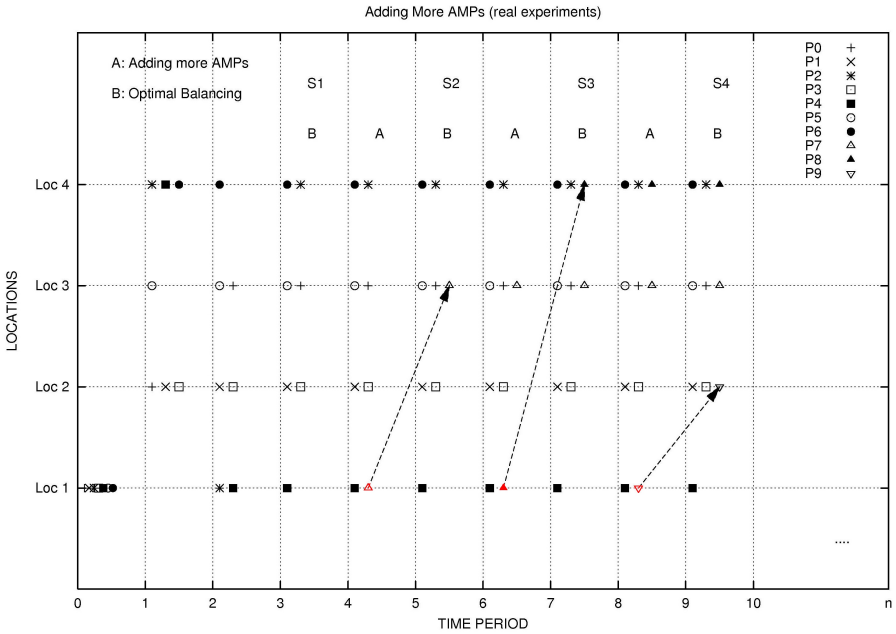

Figure: Real experiments

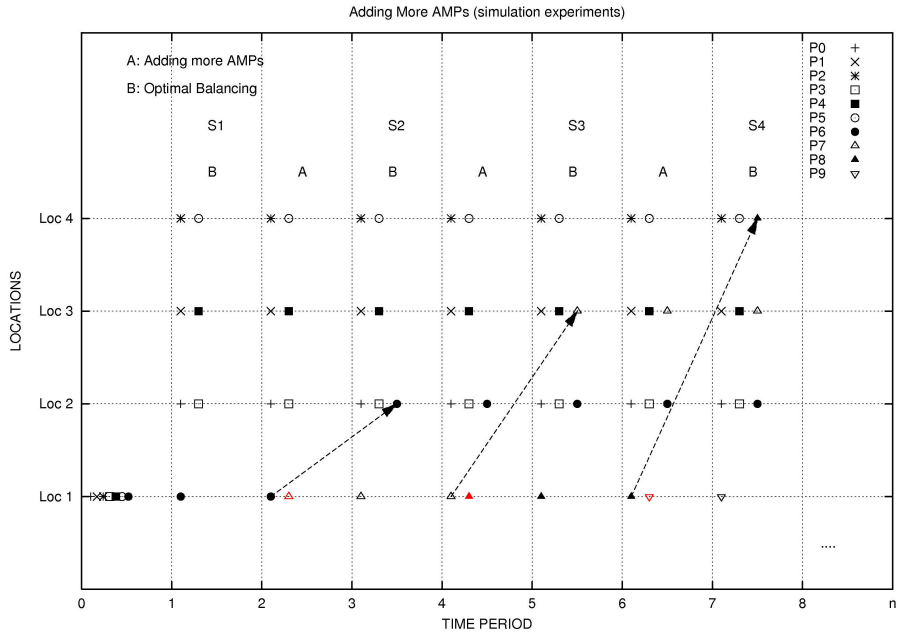

Figure: Simulation experiments

Removing AMPs

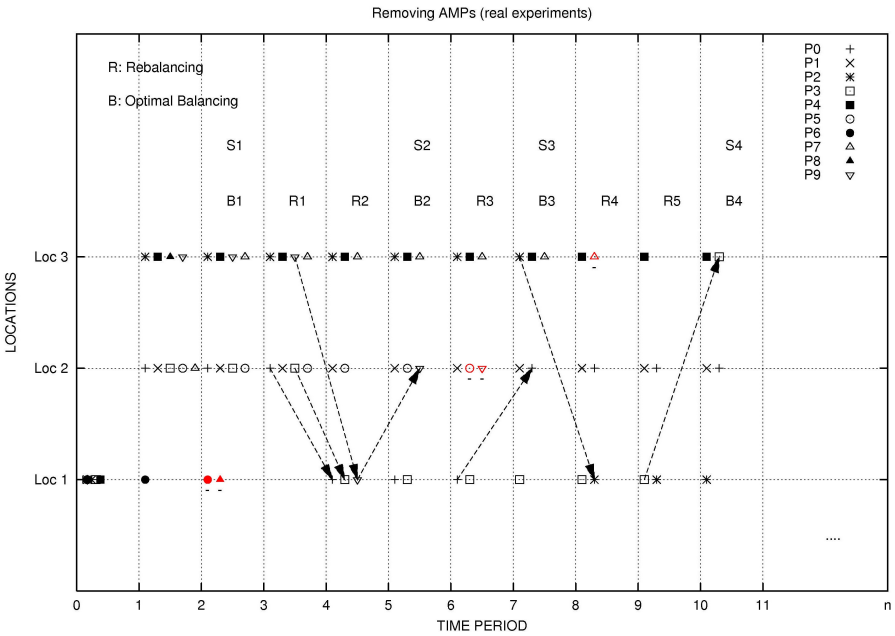

Figure: Real experiments

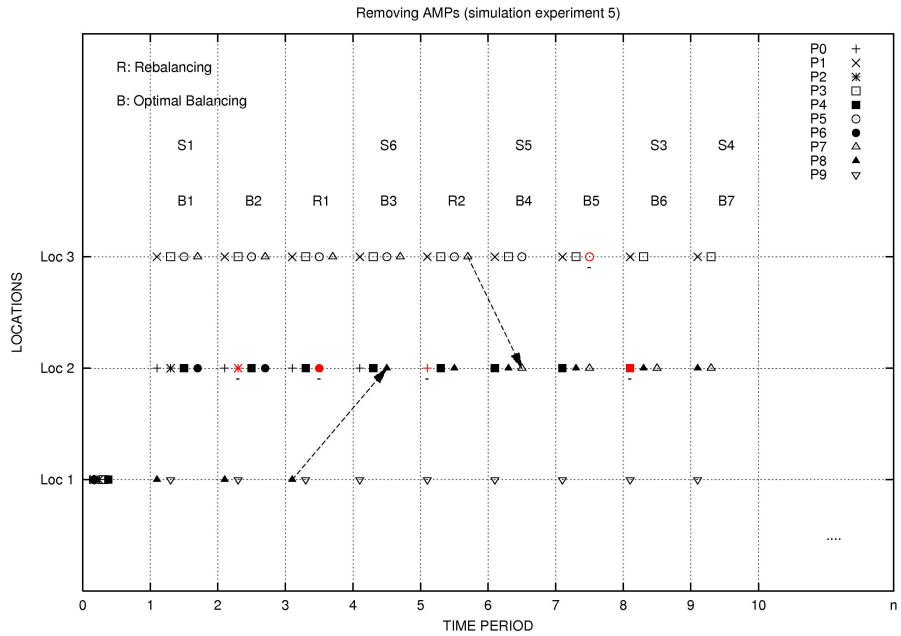

Figure: Simulation experiments

Discussion

- **Optimal Balance**. Simulation and real experiments obtain similar distribution;
- **Near-Optimal Balance**. Real and simulation results are identical;
- **Adding AMPs**. Simulation and real experiments obtain the same distribution;
- **Removing AMPs**:
  - all simulation experiments enter 3 of 4 balance states of real experiments;
  - 18% of simulation AMPs enter all states of real experiments;
  - 23% of simulation experiments have state S2 and 70% have state K2, which is also balance state.

Heterogeneous Network

- First experiment:
  - 25 AMPs;
  - 15 locations (1-5 locations - 3139 MHz; 6-10 locations - 2168 MHz; 11-15 locations - 1793 MHz).
- Second experiment:
  - 20 AMPs;
  - 10 locations (1-5 locations - 3139 MHz; 6 locations - 2167 MHz; 7-10 locations - 1793 MHz).

25 AMPs on 15 locations

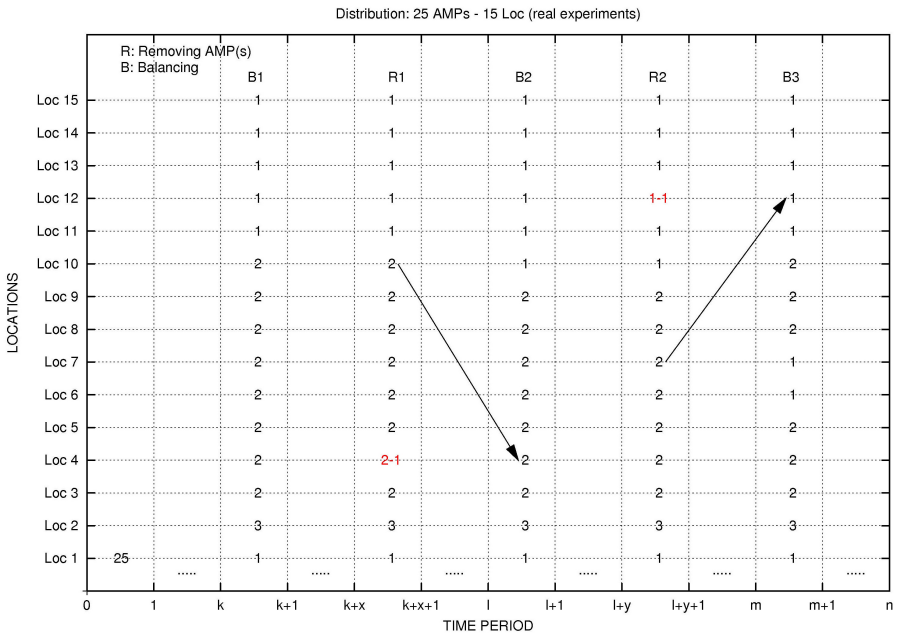

Figure: Real experiments

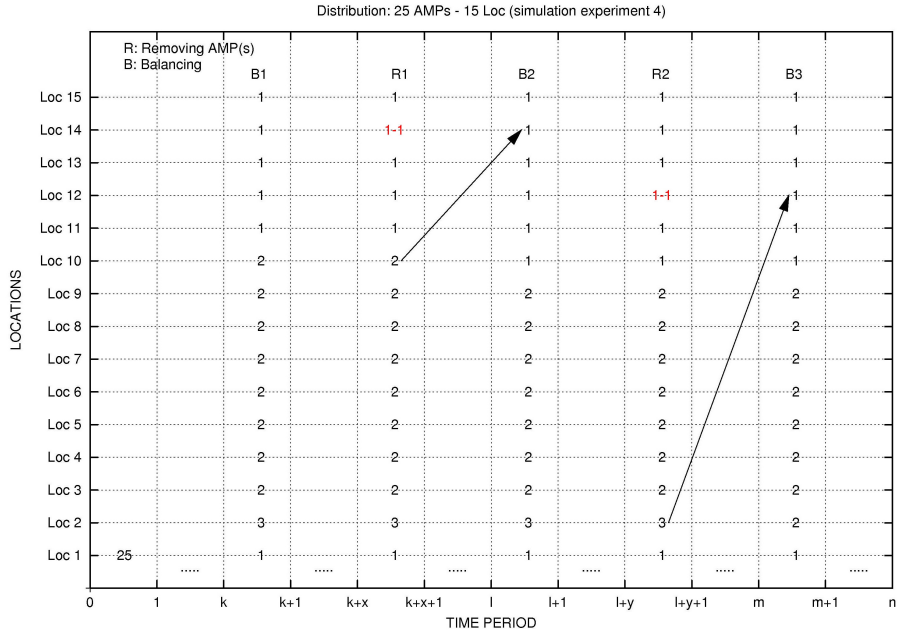

Figure: Simulation experiments

Discussion

- 41% of simulation experiments have the same distribution with real experiments, here other types of distribution are also balanced;
- in 6% of the first type simulation experiments AMPs remove from the same type of locations as in the real experiments.

Conclusion and Future Work

- **Conclusion.** Adjusted for minor differences, we can make a conclusion that current simulation model reflects real AMP behaviour and can be used for further analysis.
- **Future Work:**
  - Analysis of greedy effect on homogeneous and heterogeneous networks;
  - Further investigation of AMP behaviour on wide area networks.

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