Routing Minitask Report

Palo Alto Research Center (PARC)

Group members:

UC Berkeley (UCB)

Notre Dame (ND)

Ohio State (OSU)

Vanderbilt University (VU)

University of Virginia (UVA)

June 2004

Motivation

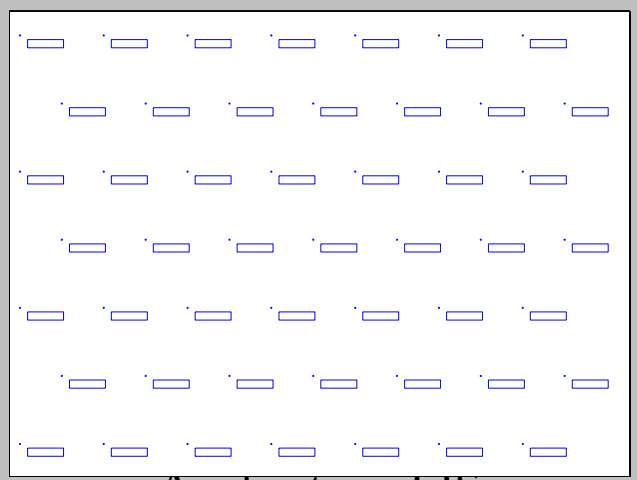
- **Routing Modeling:**
  - ✓ *Networks*
  - ✓ *Applications*
  - ✓ *Metrics*
- **Layered Architecture:**
  - ✓ *Algorithm Repository*
  - ✓ *Component Sharing*
  - ✓ *Plug and Play*

- **Routing Strategies:**
  - ✓ *Tree-based*
  - ✓ *Flooding-based*
  - ✓ *Search-based*
- **Application Scenarios:**
  - ✓ *Dynamic-to-static*
  - ✓ *Dynamic-to-mobile*
  - ✓ *Many-to-one*

Rmase

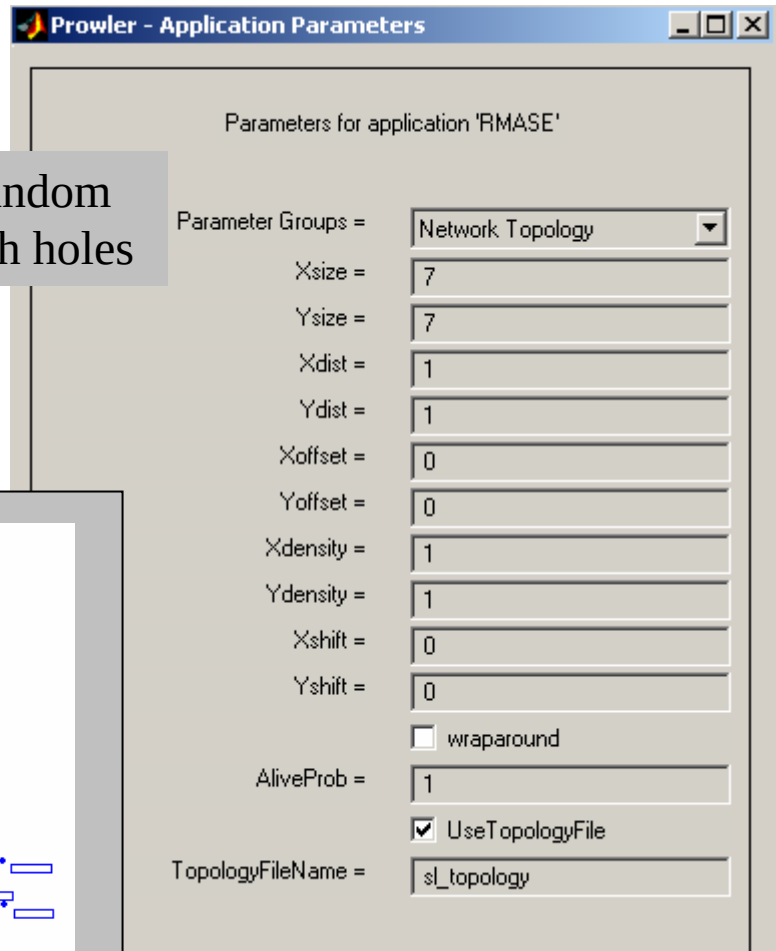
Application-oriented Routing Strategy Comparisons

Rmase Modeling: Network Topology

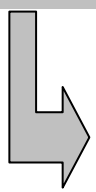


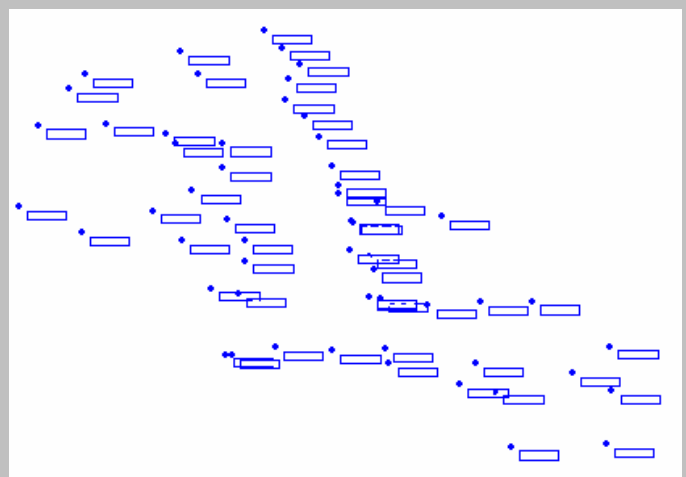
Application: LIS

Uniform or random networks, with holes



User given topologies



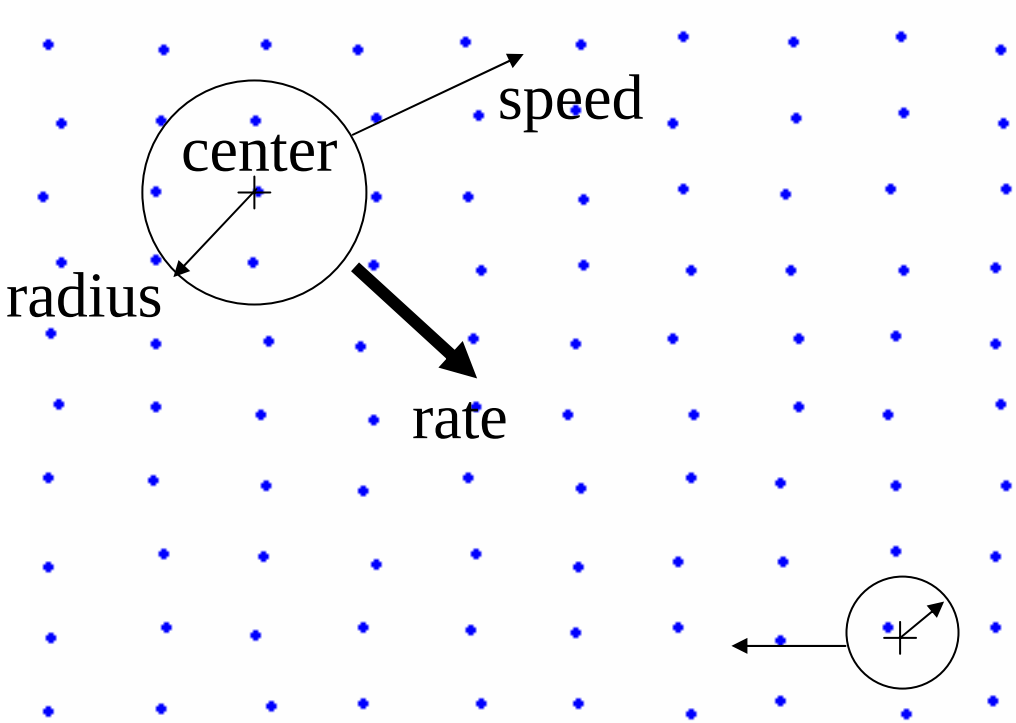


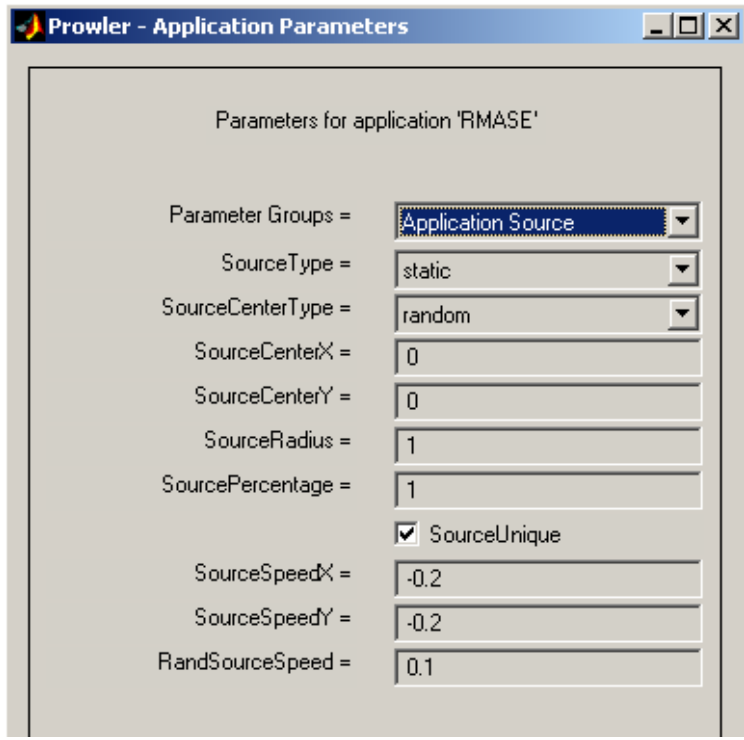
Application: SL

Rmase Modeling: Application Scenarios

User given trace: (ID, Time)

Source





Destination

Rmase Modeling: Performance Metrics

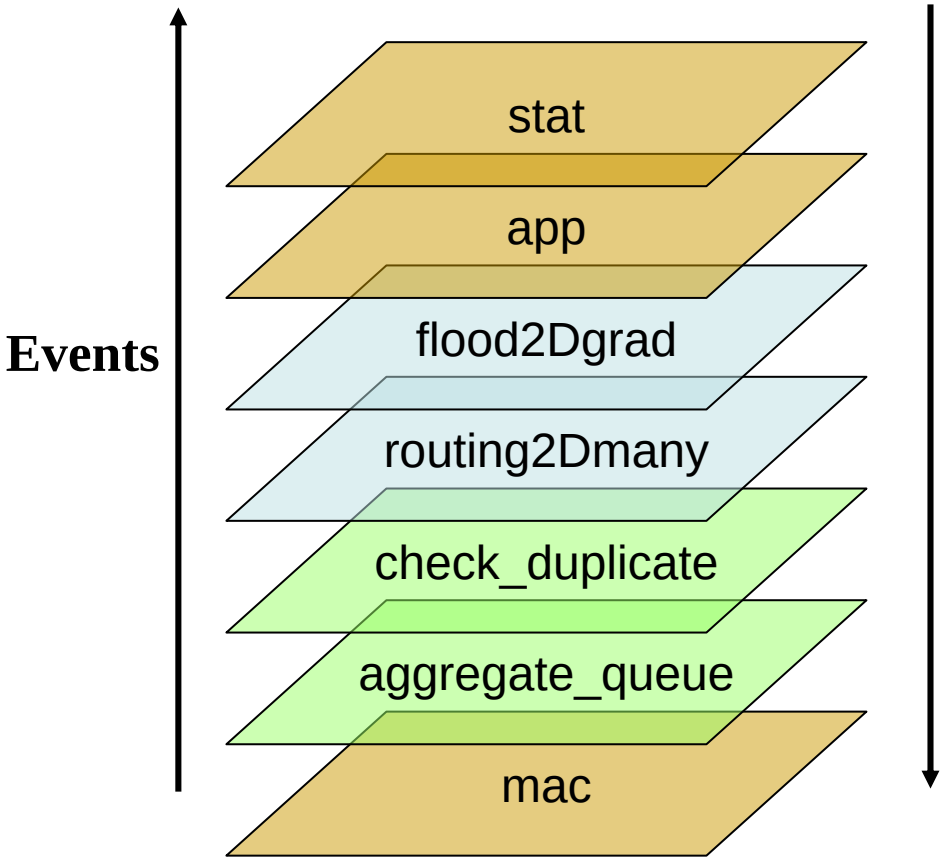
- ↓ Latency (s): $T_{received} - T_{sent}$
- ↑ Throughput (p/s): R/T
- ↓ Loss Rate: $L/(L+R)$
- ↑ Success Rate: $\Sigma R/\Sigma S$
- ↓ Energy Use: ΣU
- ↑ Energy Efficiency: $\Sigma R/\Sigma U$
- ↑ Lifetime Predication: $E_{max} - (\underline{U} + \sigma)$

$\underline{U} \leftarrow \Sigma U/N$

$\sigma^2 \leftarrow \Sigma(U-\underline{U})^2/N$

T: time
R: received packets
L: lost packets
S: original packets
U: used energy
N: total nodes
E: energy

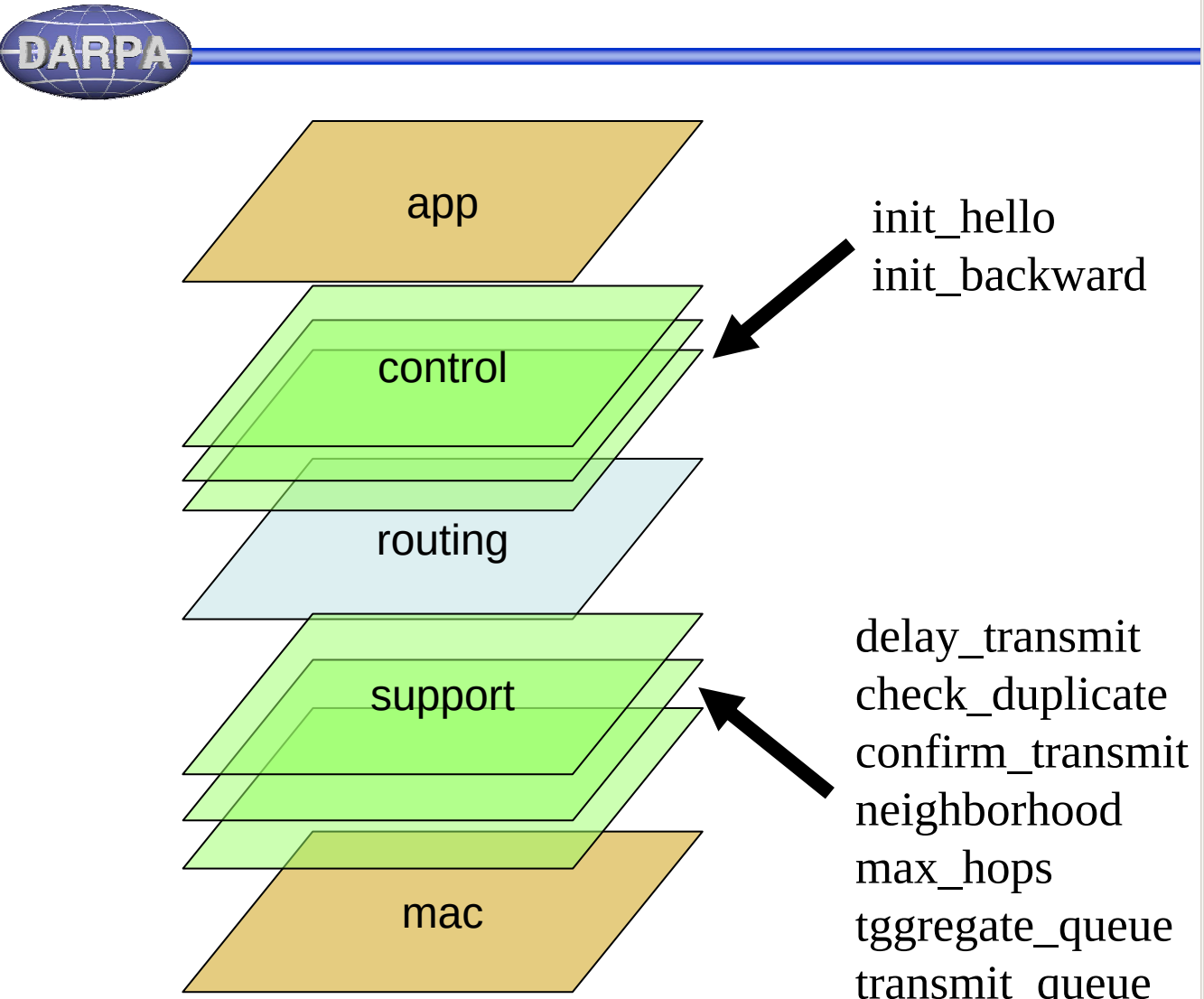
Layered Routing Architecture

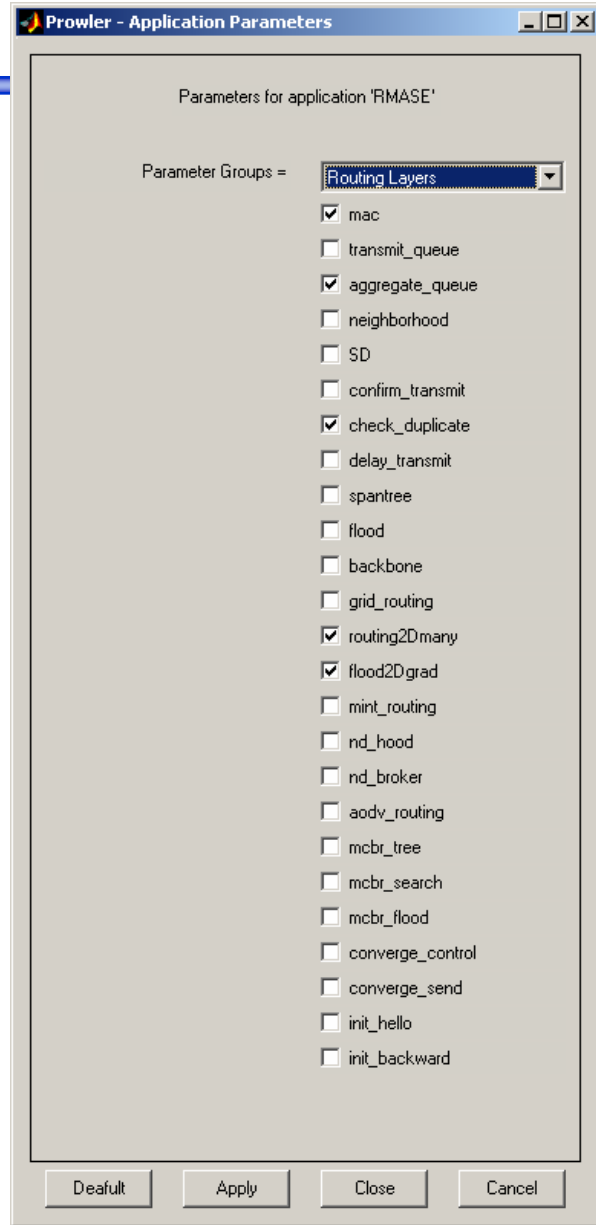


- *Motivation*
  - Component Reuse
  - Component Reconfiguration
- *General Flow*
  - Commands flow down
  - Events flow up

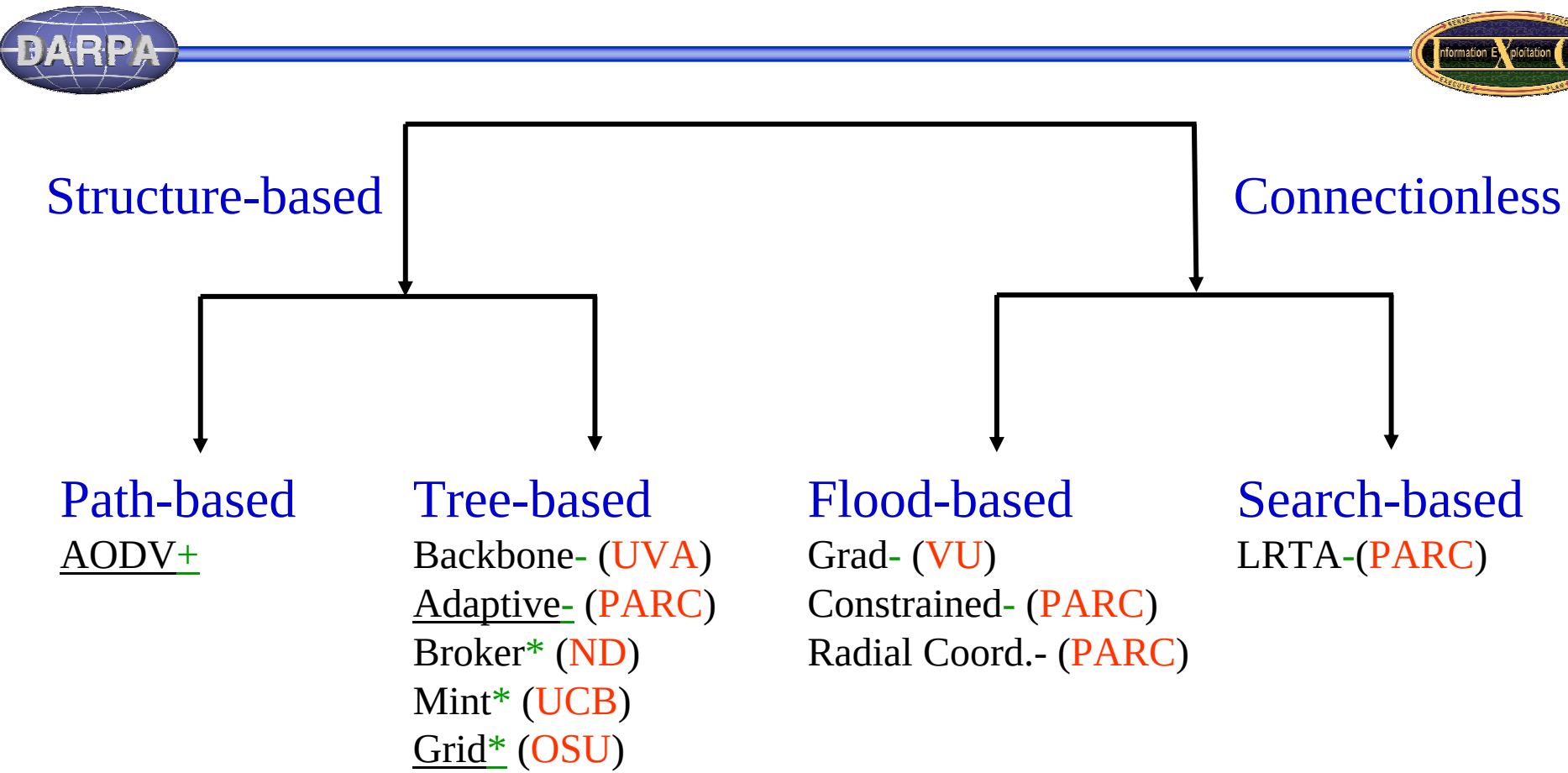
- *Commands*
  - Send_Packet
- *Events*
  - Packet_Received
  - Packet_Sent
  - Clock_Tick
  - Init_Application

Common Routing Components





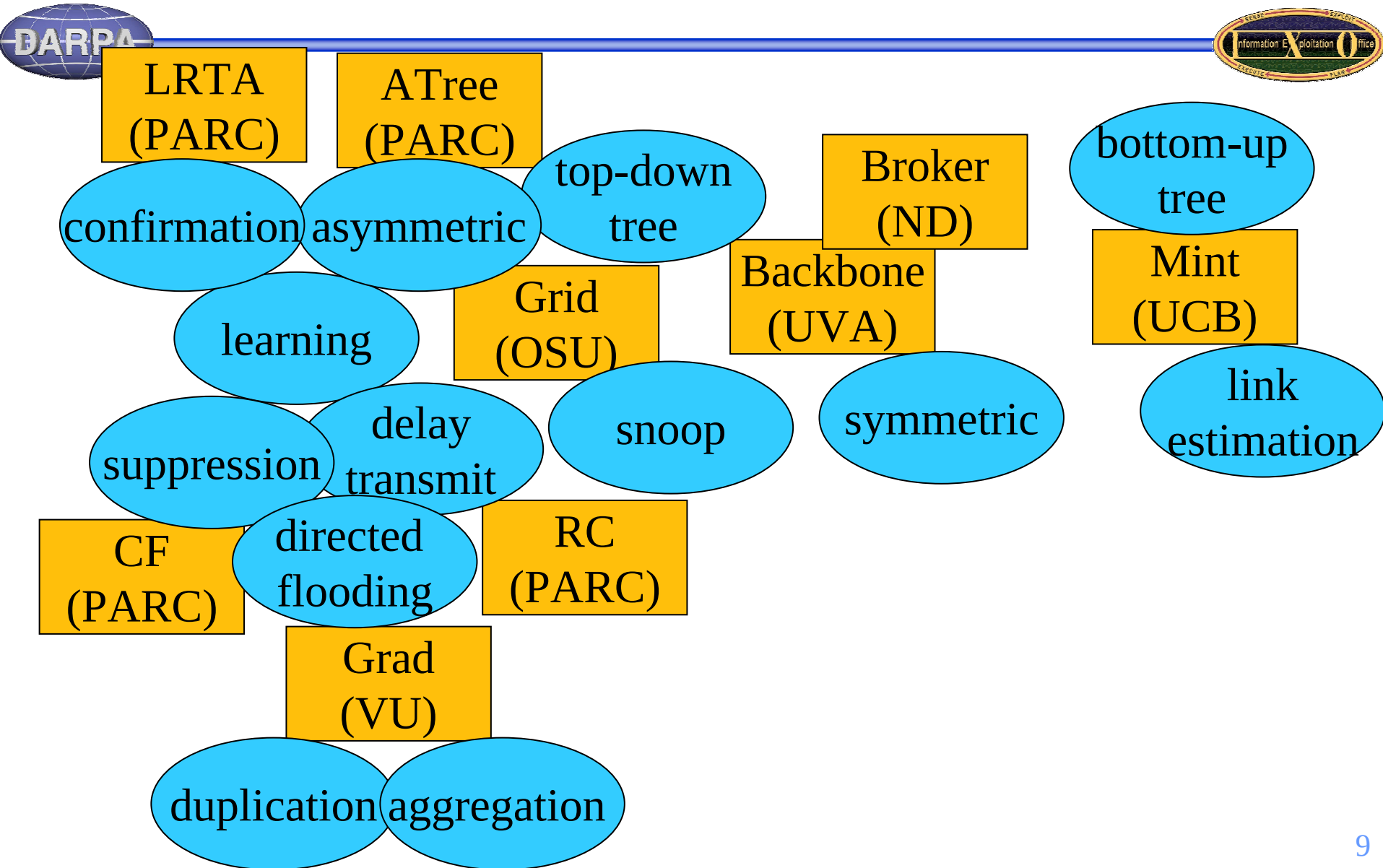
Taxonomy of Algorithm Repository



Control Packets: *: periodic, -: initialization, +: repair

Structure Maintenance: asymmetric, symmetric

Component Strategies of Routing Algorithms



Application-oriented Comparisons

- Assumptions
  - Radio Model:

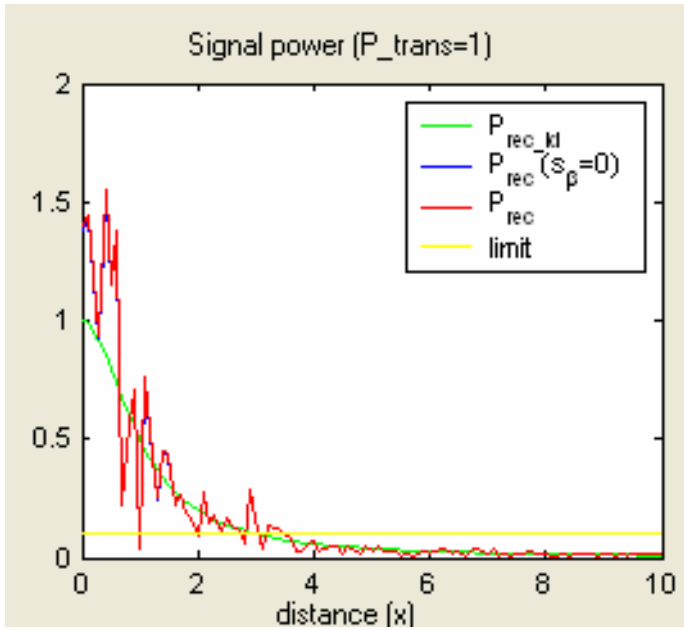
$$P_{rec,ideal}(d) \leftarrow P_{transmit}\frac{1}{1+d^{\gamma}}$$

$$P_{rec}(i,j) \leftarrow P_{rec,ideal}(d_{i,j})(1+\alpha(i,j))(1+\beta(t))$$

$$\alpha : N(0,\sigma_{\alpha}), \sigma_{\alpha} \leftarrow 0.45$$

$$\beta : N(0,\sigma_{\beta}), \sigma_{\beta} \leftarrow 0.02$$

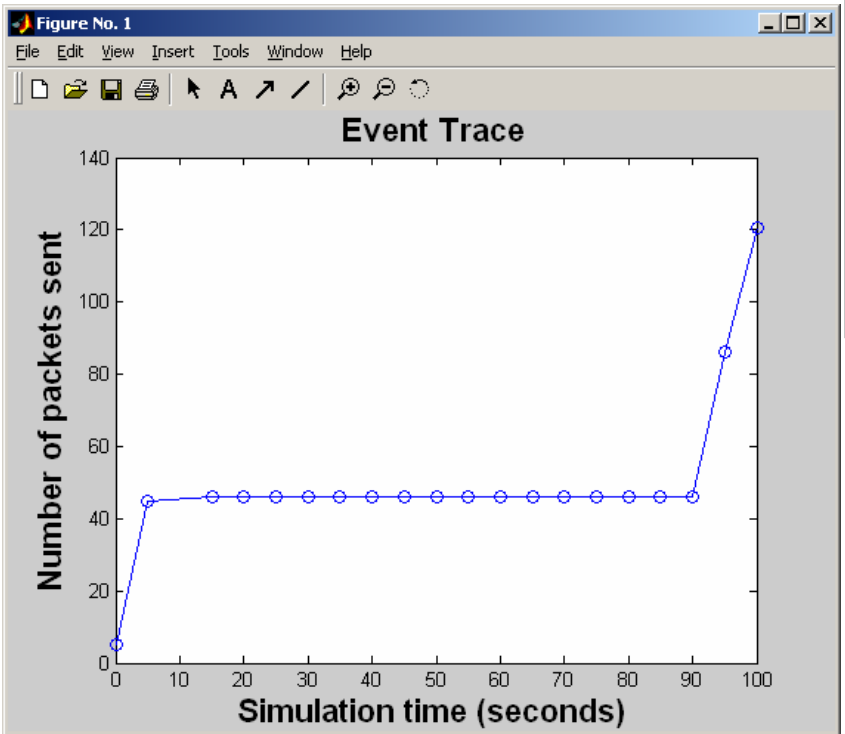
$$i \leftarrow j \Leftrightarrow P_{rec}(i,j) > \Delta$$

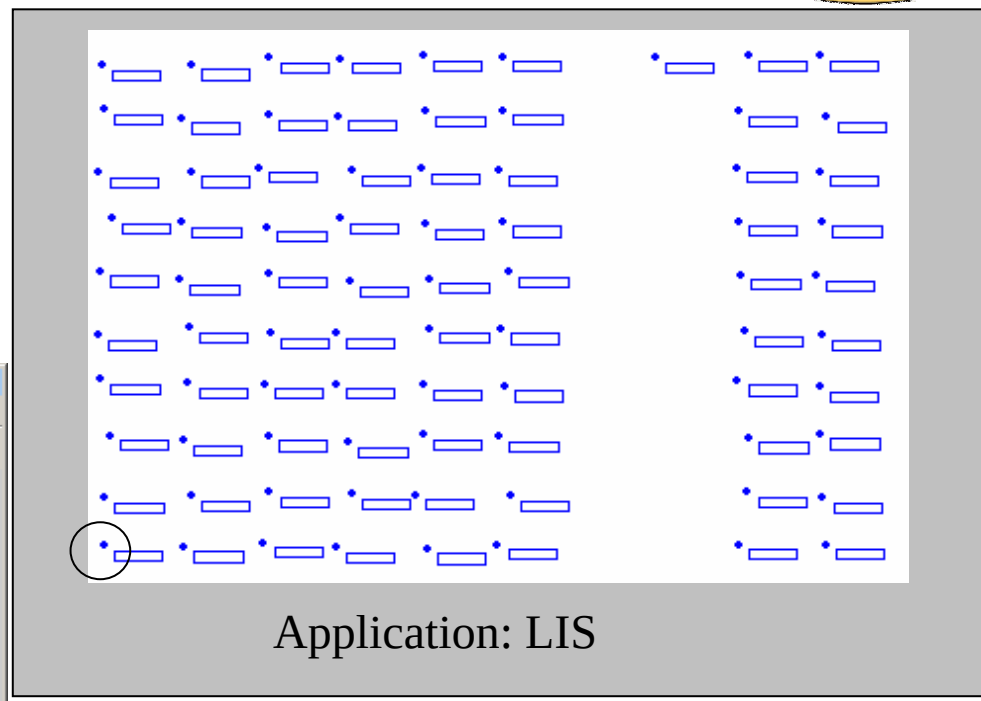


  - Radio Strength: constant
  - Algorithm Parameters: default
- Applications
  - LIS: A Line in the Sand (OSU)
  - RFT: Red Force Tagging (ND)
  - PEG: Pursuer/Evader Game (UCB)
  - SL: Shooter Localization (VU)
  - OSU: OSU Testbed (OSU)

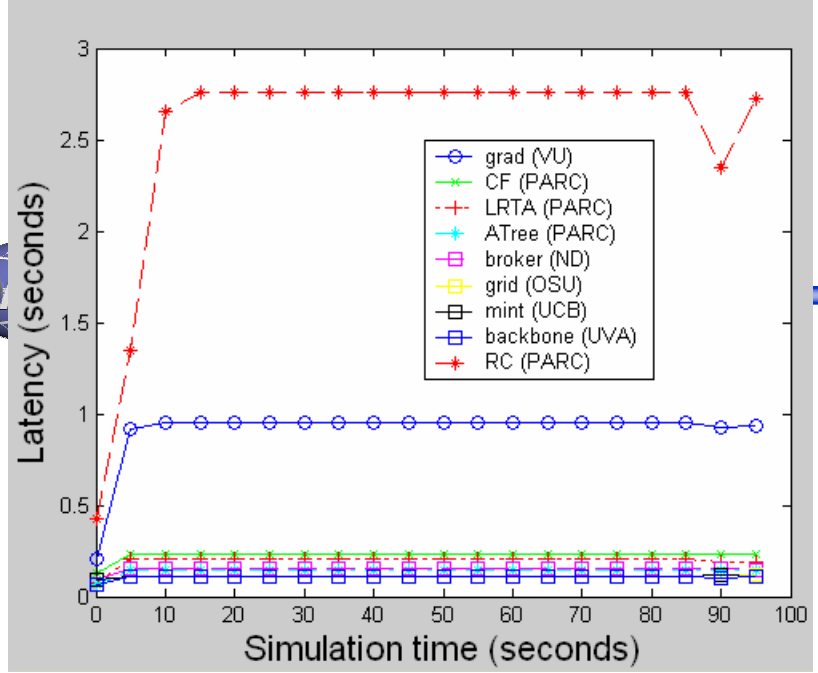
A Line in the Sand

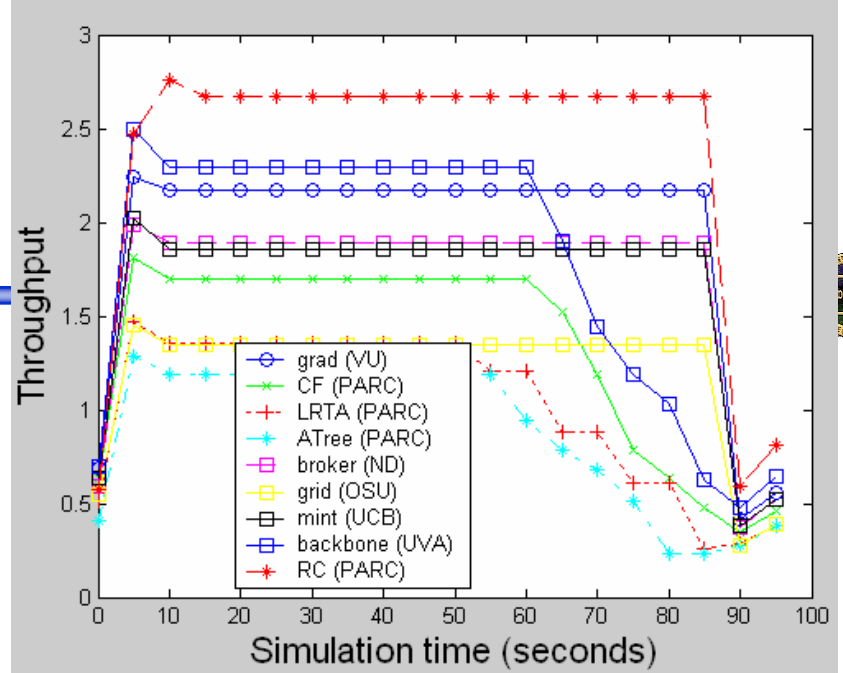
- Source: given trace
- Destination: static at (0,0)
- Simulation time: 100 s
- Total runs: 10



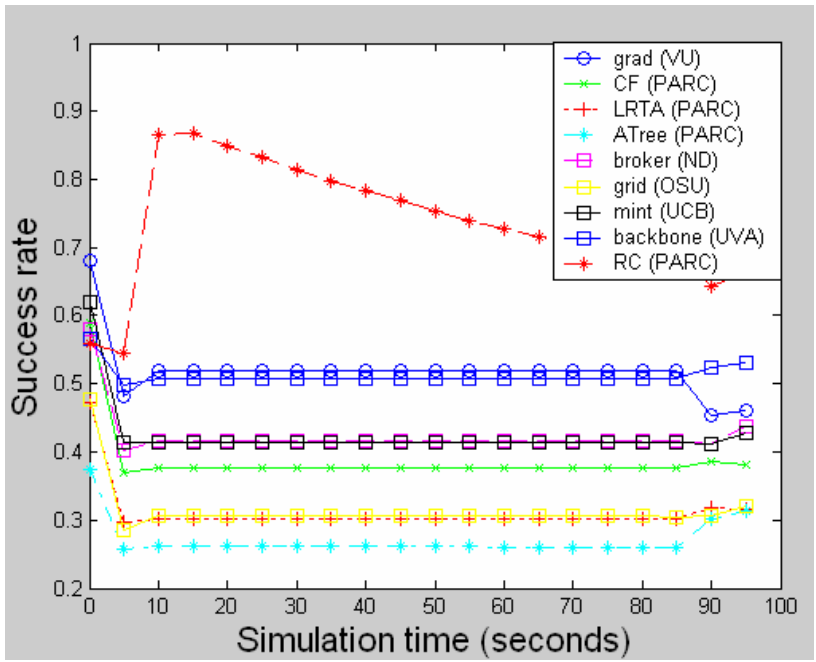


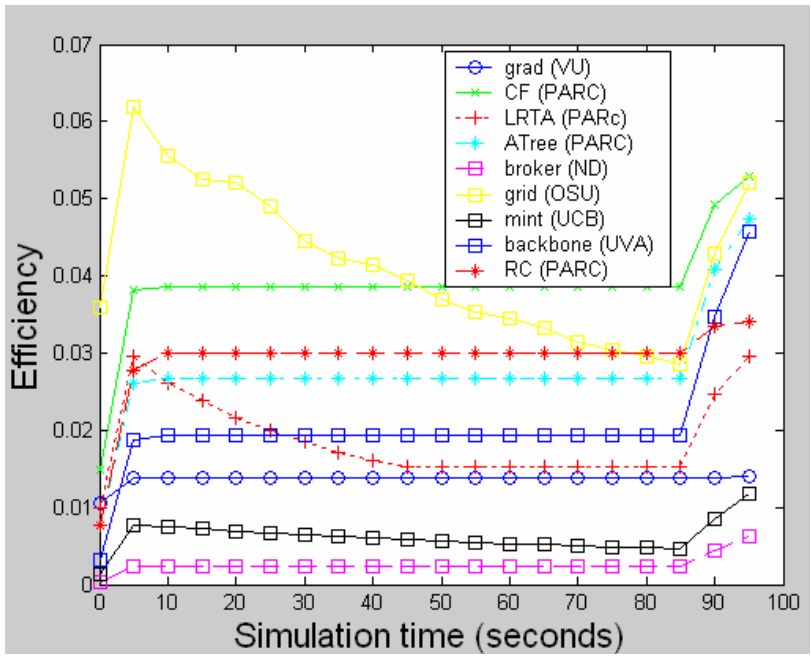
Application: LIS





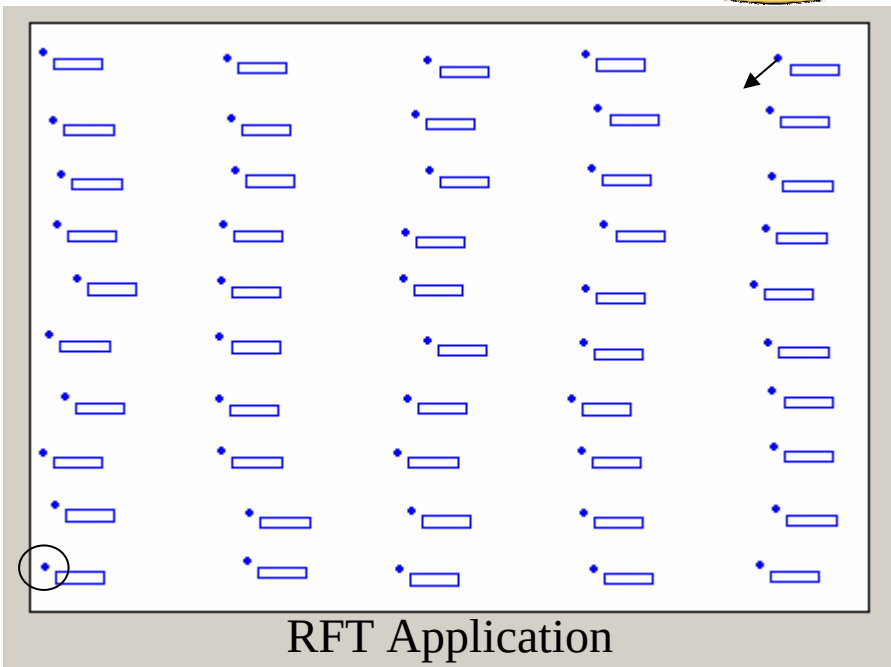
LIS Experiments

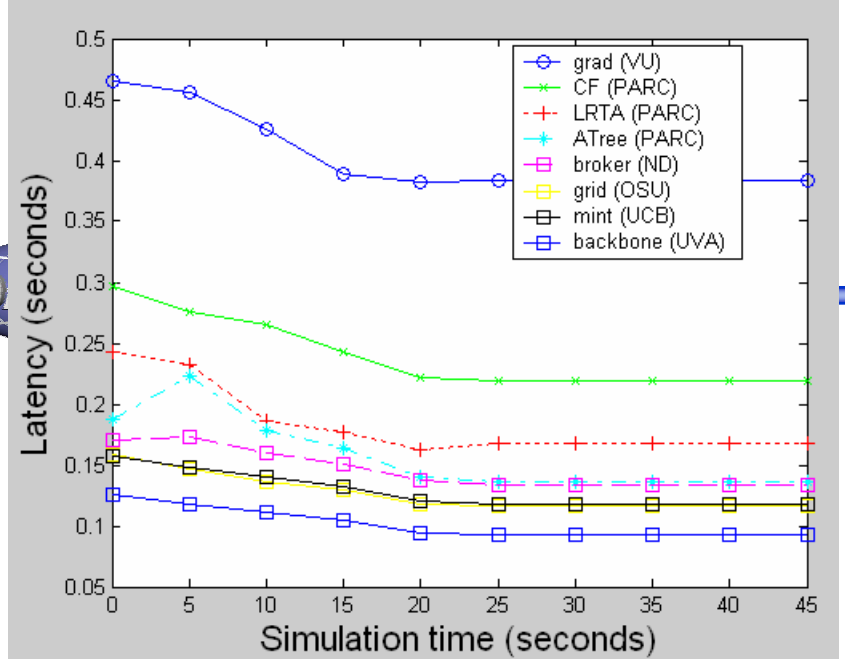


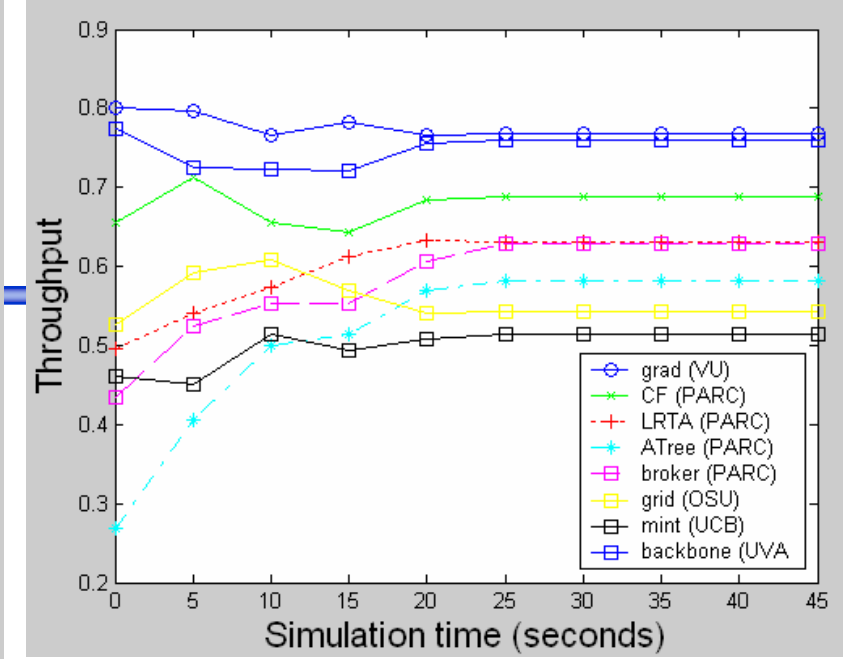


Red Force Tagging

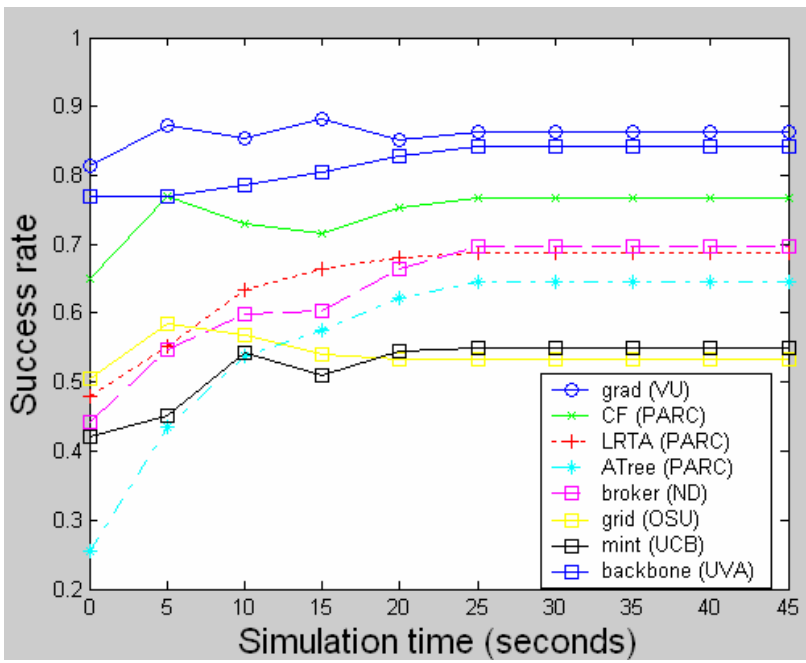
- Source:
  - dynamic, speed 0.2/s
  - Rate 1p/s
- Destination:
  - static at (0, 0)
- Simulation time: 50 s
- Total runs: 10

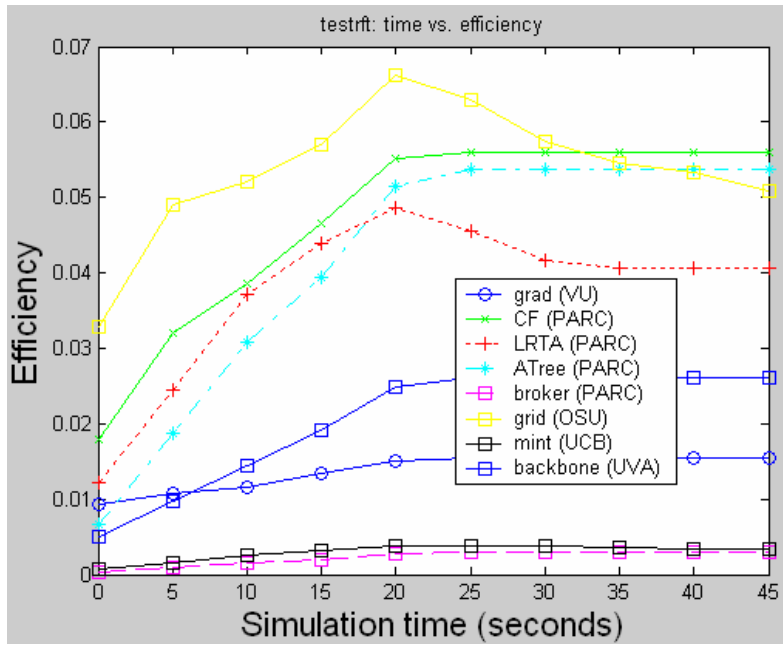

RFT Application





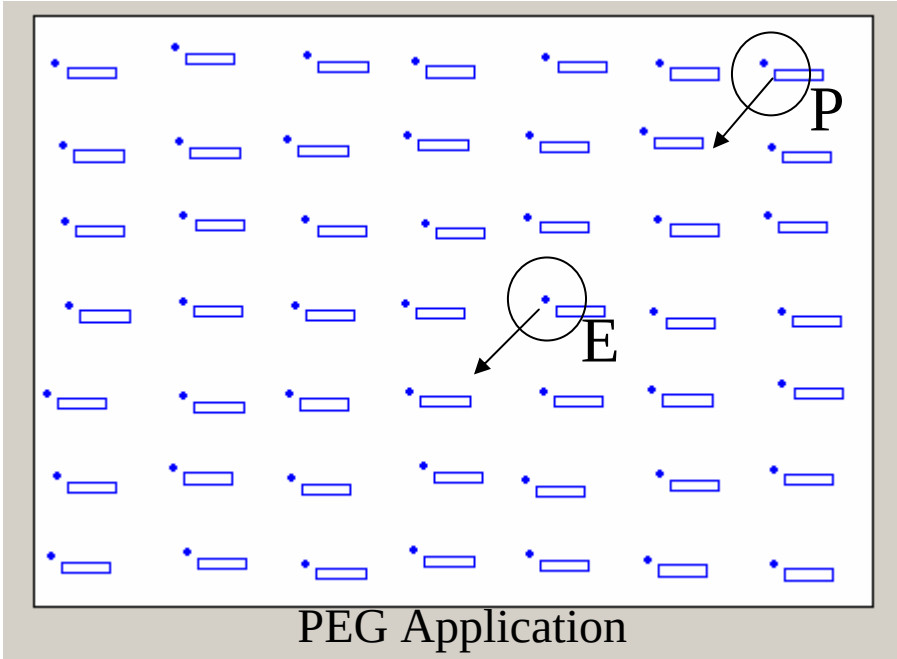
RFT Experiments



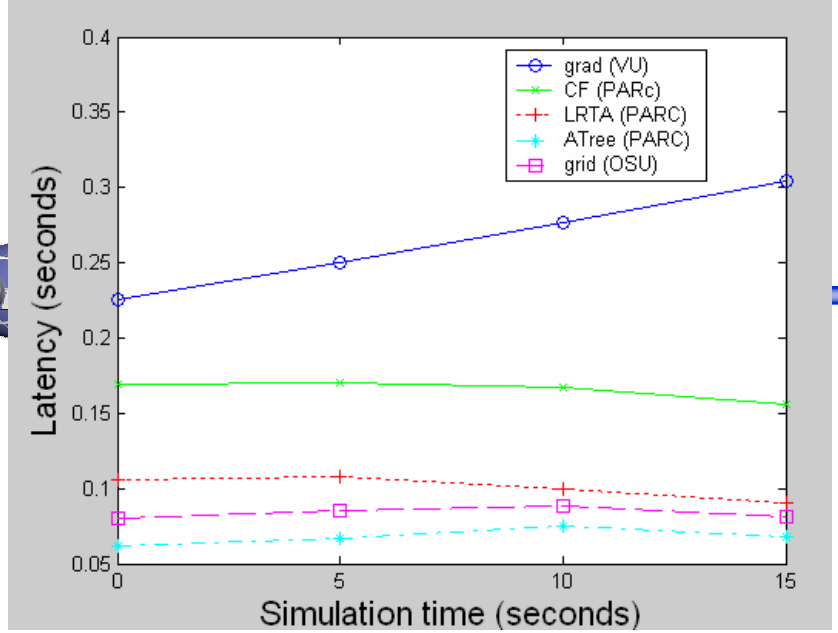


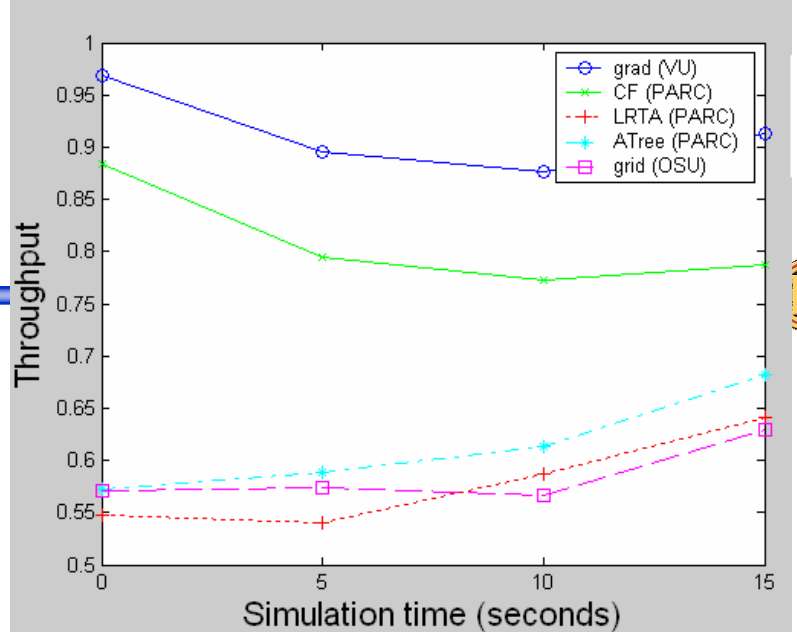
Pursuer/Evader Game

- Source:
  - dynamic, speed 0.2/s
  - Rate 1p/s
- Destination:
  - Mobile, speed 0.2/s
- Simulation time: 20 s
- Total runs: 10

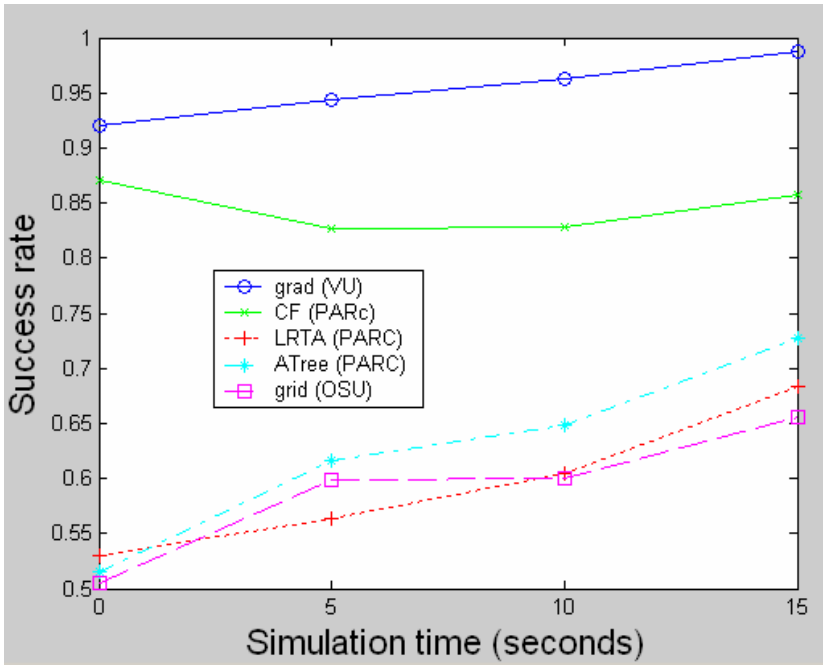


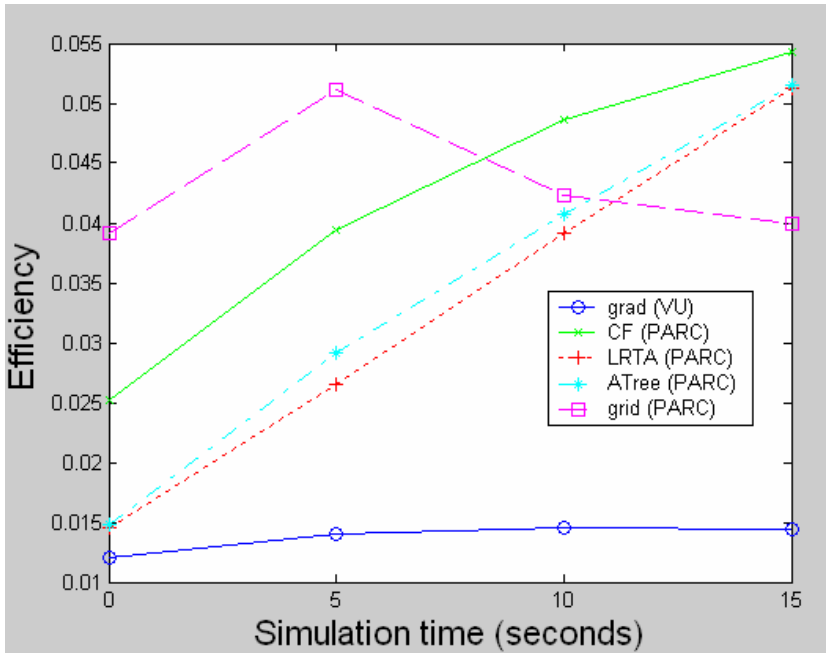
PEG Application





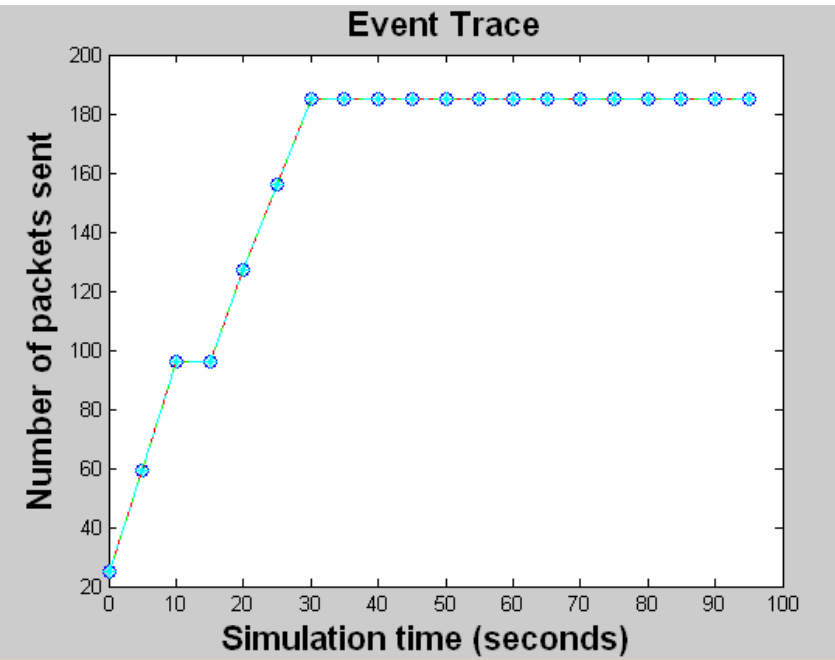
PEG Experiments

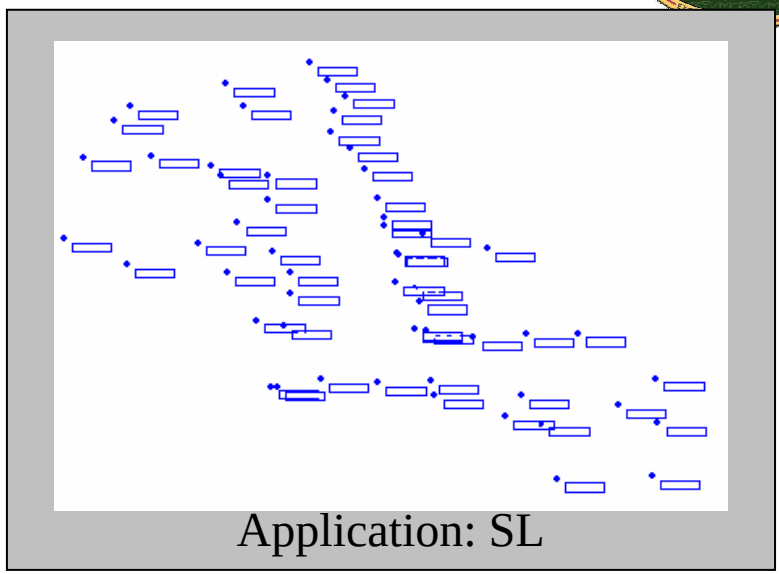


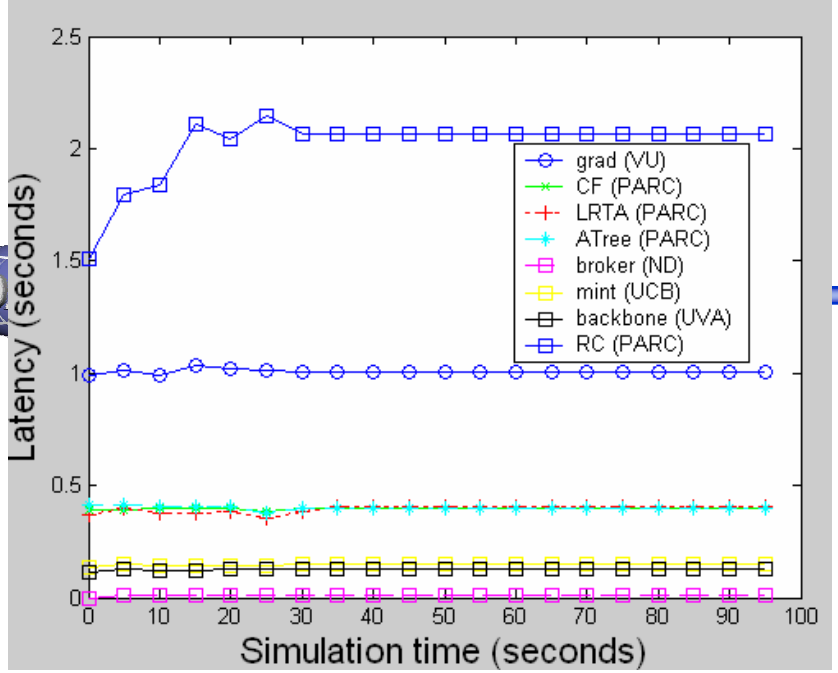


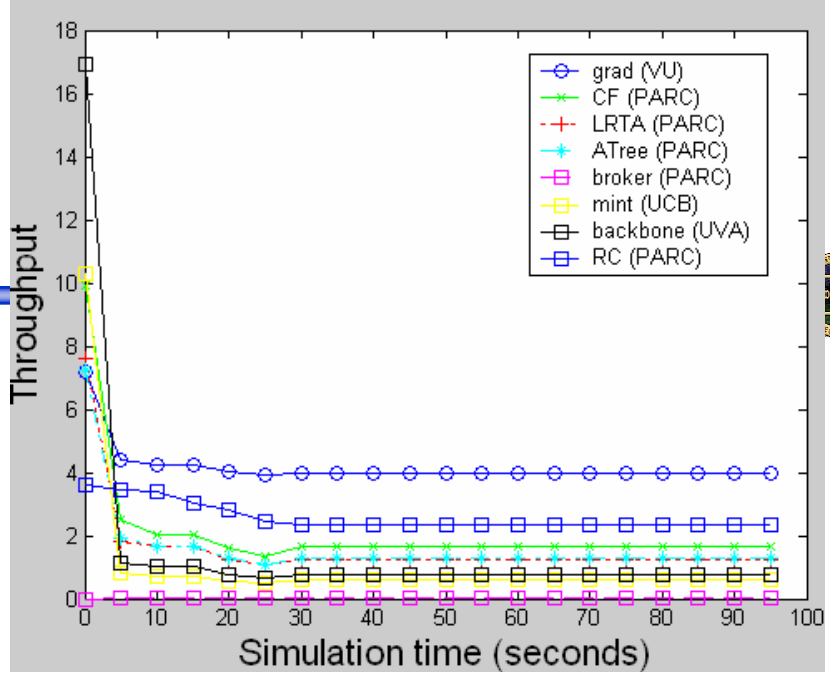
Shooter Localization

- Source: given trace
- Destination: static given
- Simulation time: 100 s
- Total runs: 10

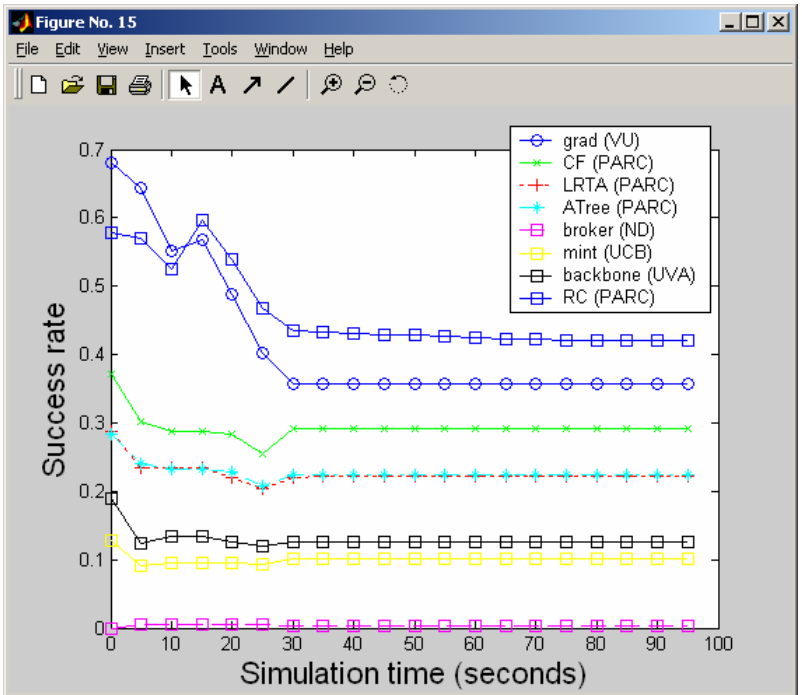


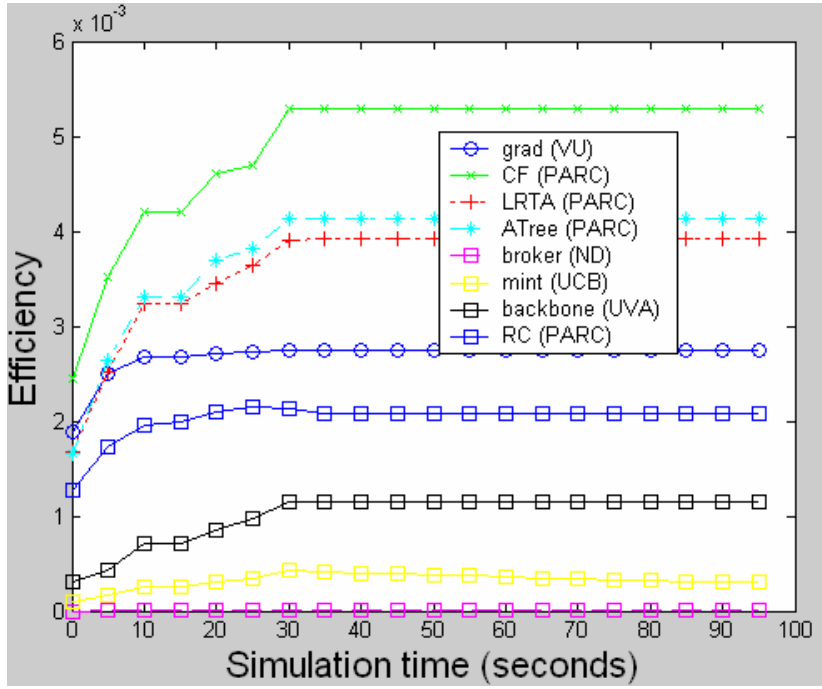

Application: SL





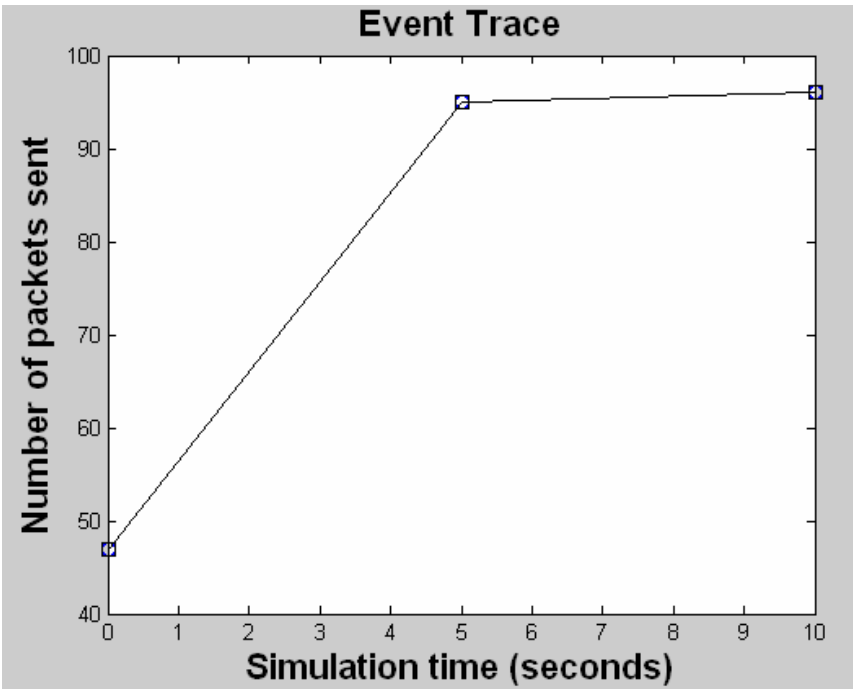
SL Experiments

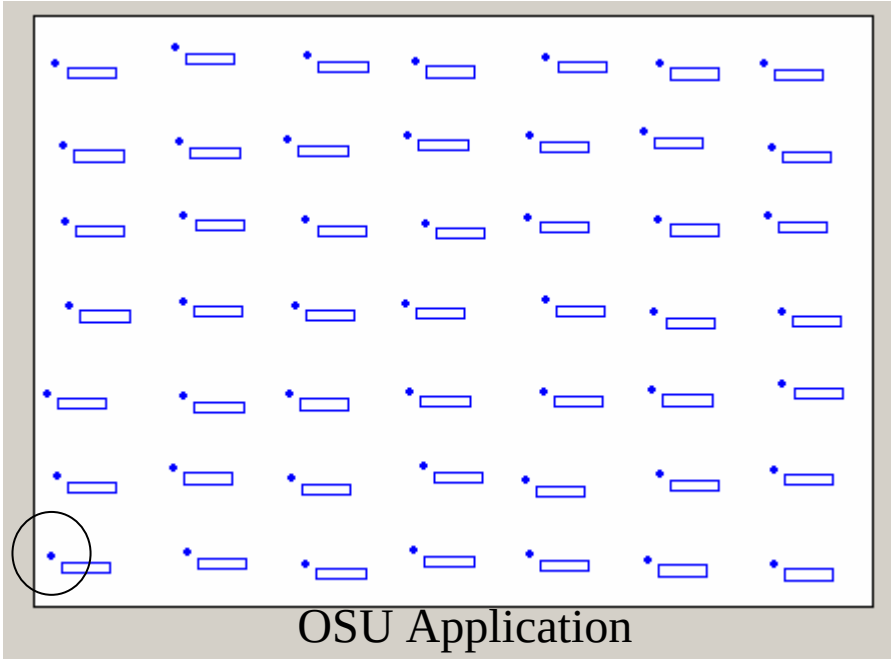




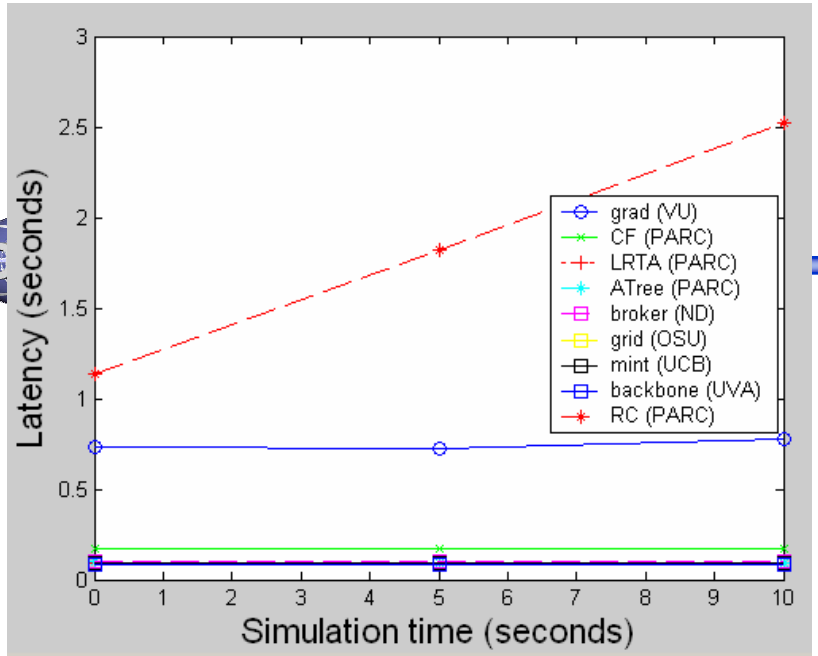
OSU Testbed

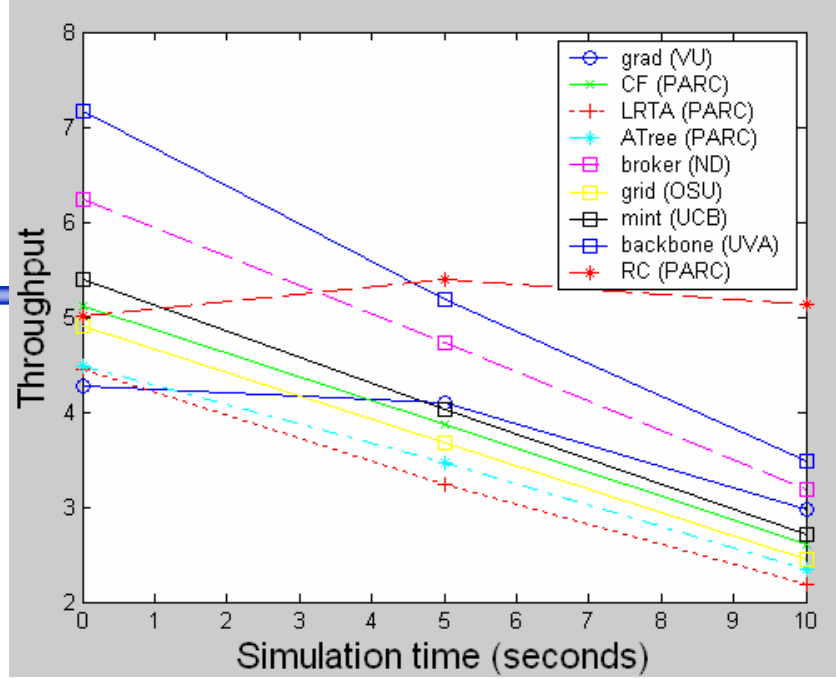
- Source: give trace
- Destination: static at (0, 0)
- Simulation time: 15 s
- Total runs: 10



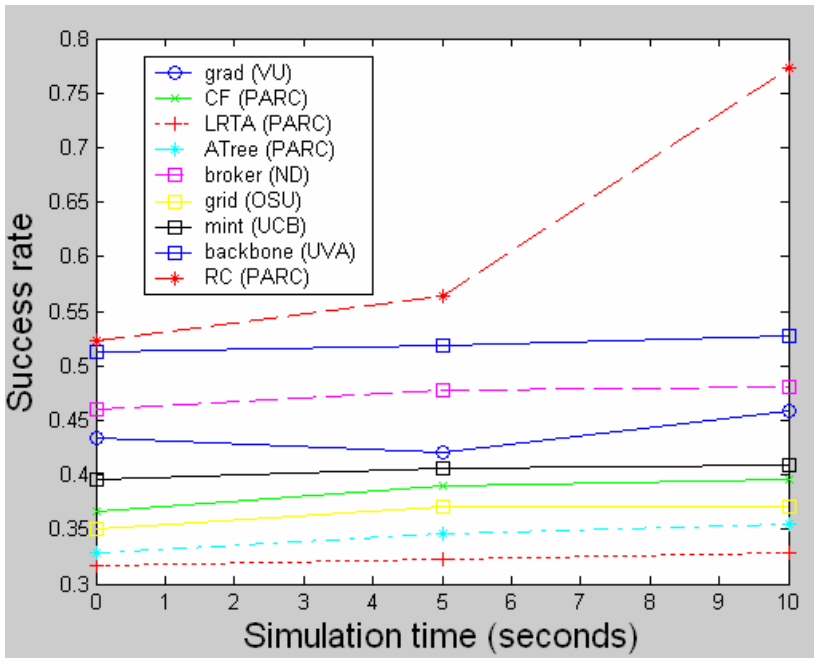


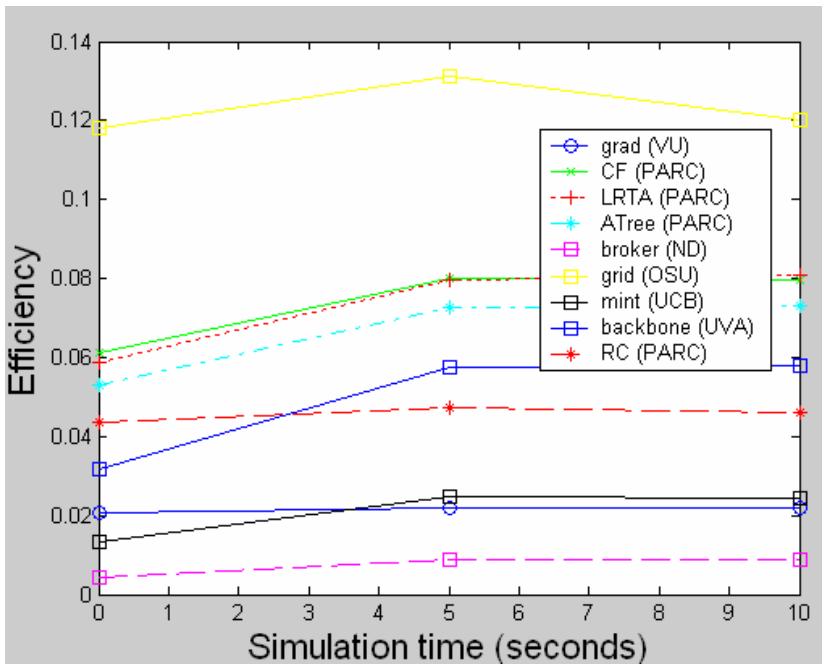
OSU Application





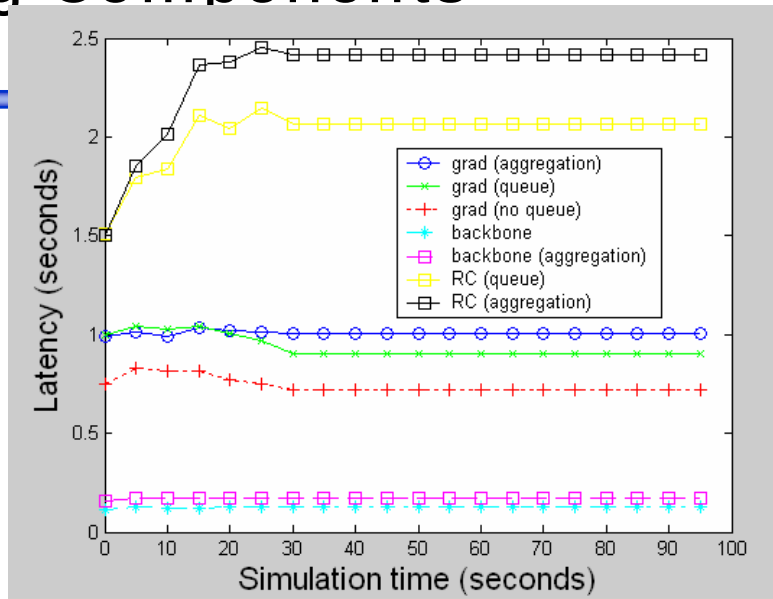
OSU Experiments

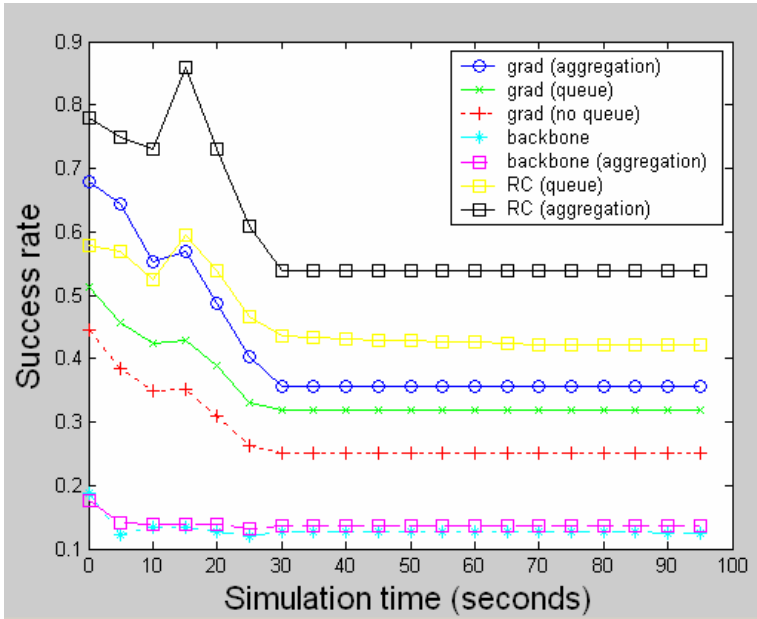




Plug-Play Routing Components

- grad:
  - with aggregation
  - with transmit queue
  - without queue
- RC:
  - with aggregation
  - with transmit queue
- backbone:
  - with aggregation
  - without aggregation



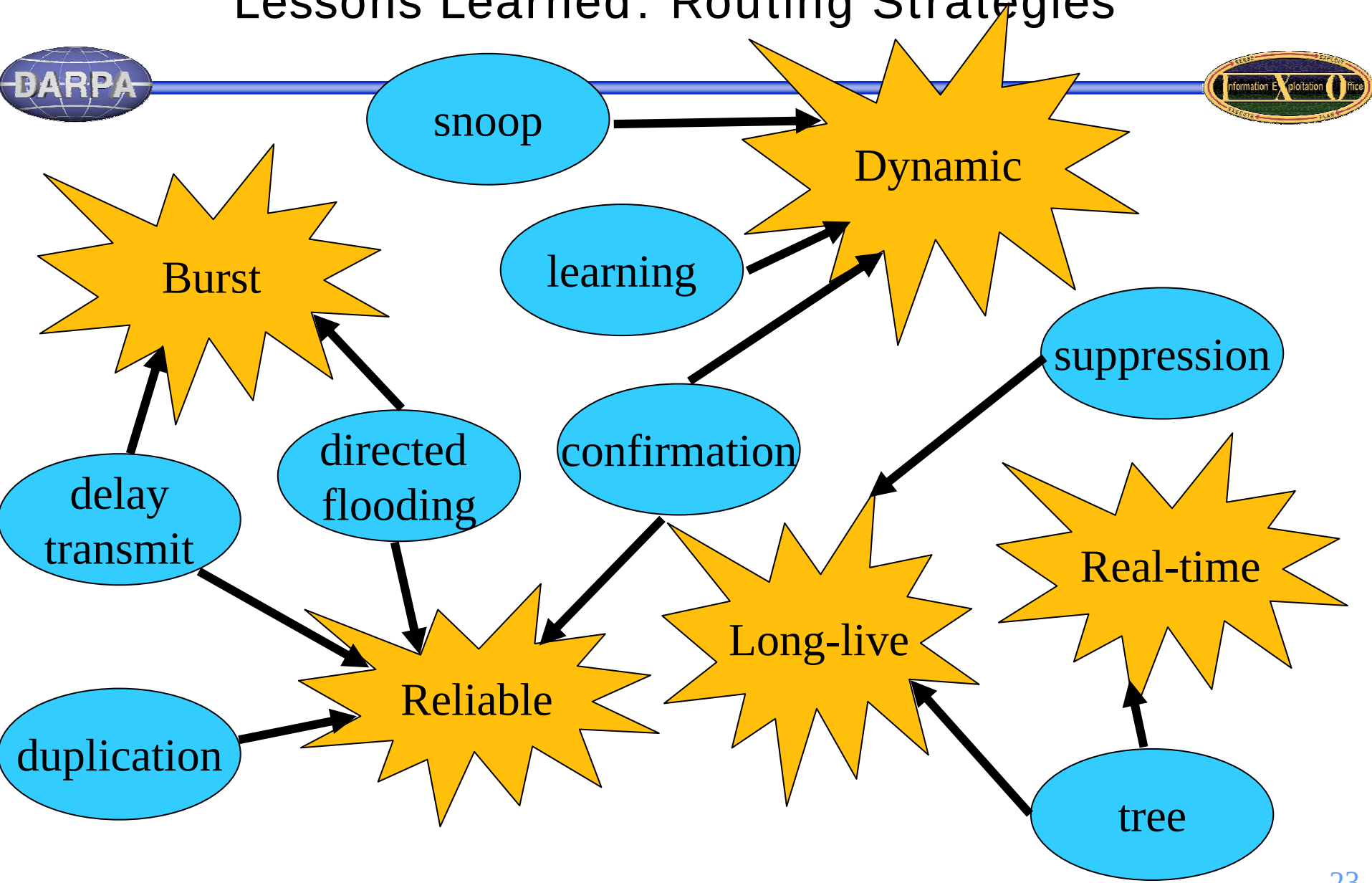


Lessons Learned: Modeling and Simulation

Rmase

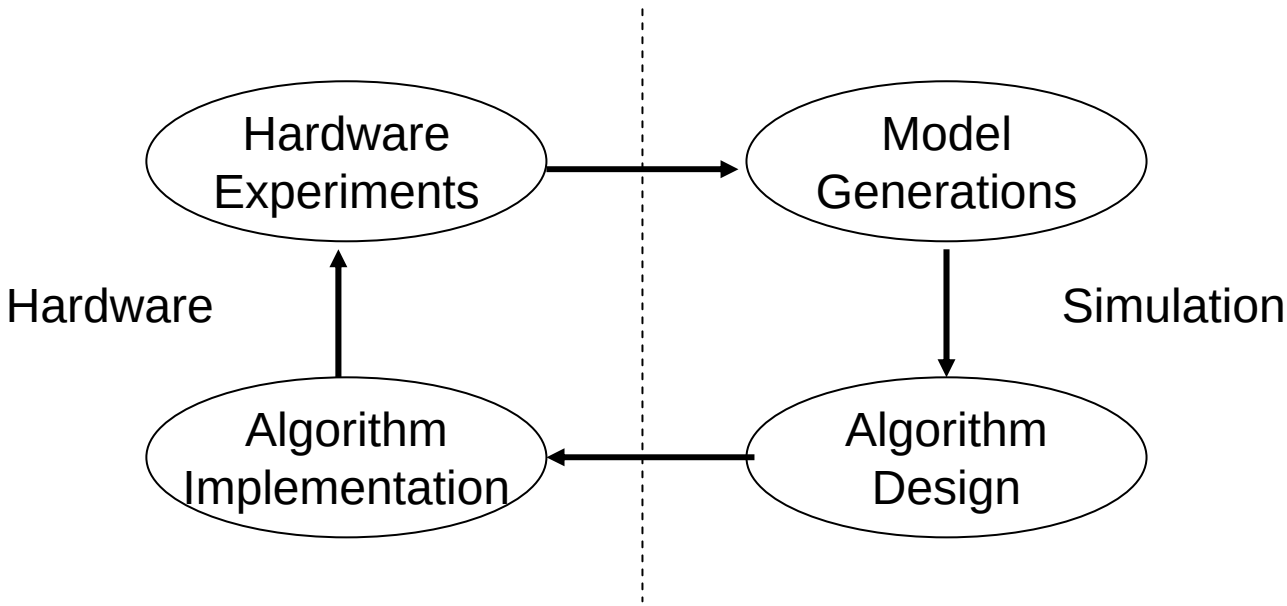
- Plug/play reusable routing components
- Model routing applications
- Analyze routing algorithms
- Optimize routing performance

Lessons Learned: Routing Strategies



Take Away Points

- **Performance of routing strategies depends on**
  - the network and application types
  - metrics the application cares about
- **The relationship between simulation and hardware**
  - Simulation makes assumptions
  - Hardware verifies assumptions



Thanks

- Young-ri Choi (OSU/UTexas), Hongwei Zhang (OSU)
- Miklos Maroti (VU), Manish Kushwaha (VU)
- Marian Iordache (ND)
- Alex Woo (UCB)
- Tian He (UVA)