

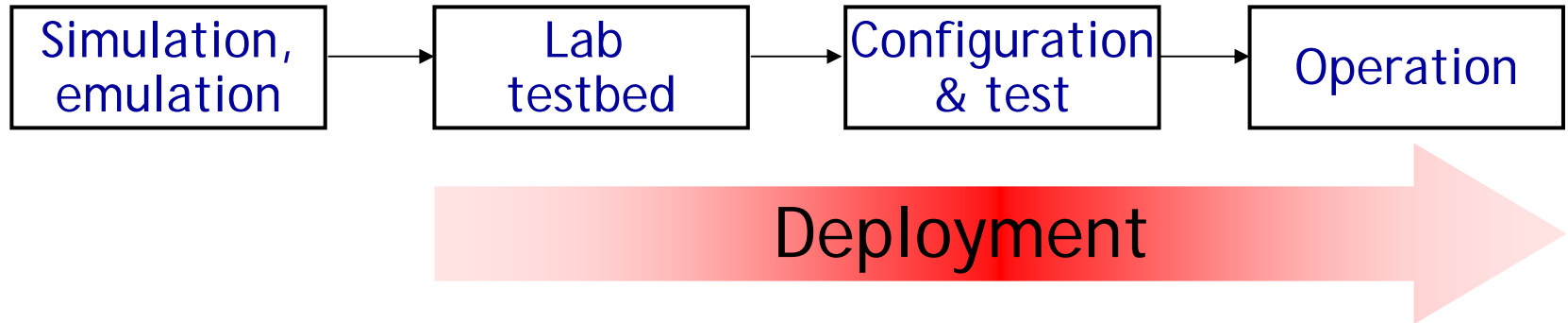


Deployment of Sensor Networks

Concepts and Tools

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Deployment



- Setting up an operational sensor network
 - Real-world settings
 - Large number of nodes
 - For realistic applications
- Key issue for real-world applications
- Requires new concepts and tools

Methodological Gap



- **Large gap** between simulation/testbed and operational real-world application
 - Working simulation/testbed  operation
- Reasons
 - Simulation: does not capture all real-world effects
 - Testbed: few nodes, controlled environment
 - Users: Application experts, not system experts

Deployment as an Art

- Deployment issues are not well understood and mastered today
 - Almost no abstractions, few tools
- Tools mainly for simulation
 - TOSSIM, SENS, ...
- Small-scale, wired testbeds
 - Gnomes, MoteLab, Mirage, Emstar, ...
- Experience with few larger systems (>> 100 nodes)
 - Duck island, shooter localization, ...

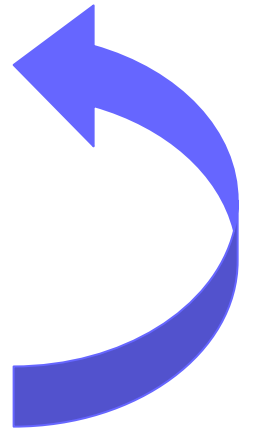
Goals and Contributions

- Goals

- Concepts and tools for efficient deployment
- Speed up development process
- Enable large real-world applications

- Contributions

- 1) Network Programming (do *this!*)
- 2) Inspection (what is it *really* doing?)
- 3) Maintenance (*how* to fix problems?)



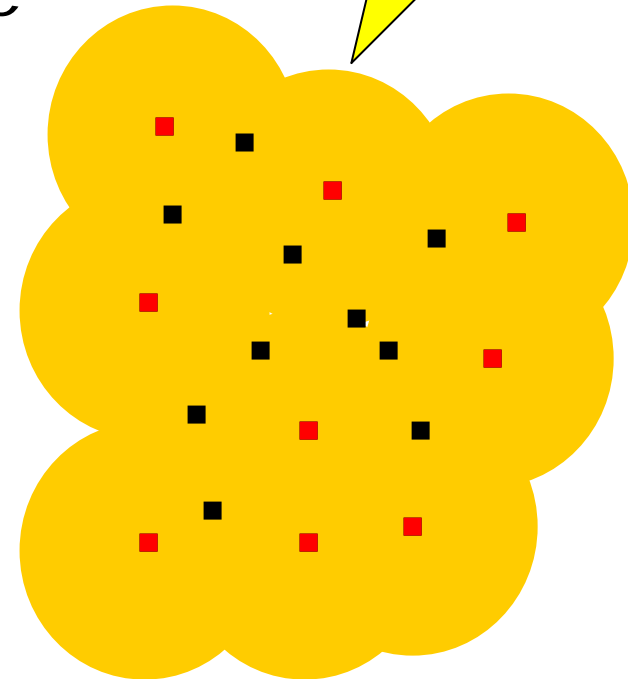
1) Network Programming

- Problem
 - Users are application experts
 - Programming is not an isolated activity
- Approach: Global Programming Model
 - Raise level of abstraction
 - Single nodes -> whole network
 - System level -> problem orientation
 - Integration with inspection and maintenance

Example: Role Assignment

- Assign functions to sensor nodes based on node properties
 - New abstraction: "roles"
- Generic specification language
 - Ex. "Coverage": determine few **ON** nodes that cover whole area with their sensors, others OFF
 - Compiled offline
- How to inspect and maintain such „programs“?

```
ON :: {  
  battery >= 50% AND  
  count (2 meters) {  
    role == ON  
  } <= 1 }  
OFF :: else
```



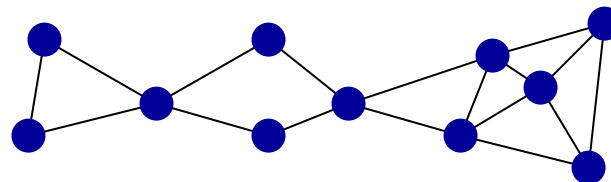
2) Inspection

- Problem
 - What is going on in the sensor network?
 - Real-world settings: no cables
 - Constrained resources: installing a probe alters behavior
- Approach: Deployment Support Network
 - Self-organizing „observation“ network

Example: Deployment Support Network

- Separate wireless network
 - Different communication channel
 - Installed temporarily alongside sensor network
- Observe sensor node states and network traffic
 - Minimum impact on sensor network
- Executes deployment-support services
- Prototype based on BTnodes

sensor network



3) Maintenance

- Identify and repair misbehavior
- Leverage Deployment Support Network
 - Energy/performance profiling
 - Distributed unit testing
 - Problem identification
 - Flexible event logging
 - Distributed watchpoints and breakpoints
 - Execution replay
 - Remote re-programming

Conclusions

- Intend to provide a *deployment platform* for sensor network applications
 - Network programming
 - Inspection
 - Maintenance
- We are sitting between applications and sensor node platforms
- Need to understand
 - Application requirements
 - Platform characteristics



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