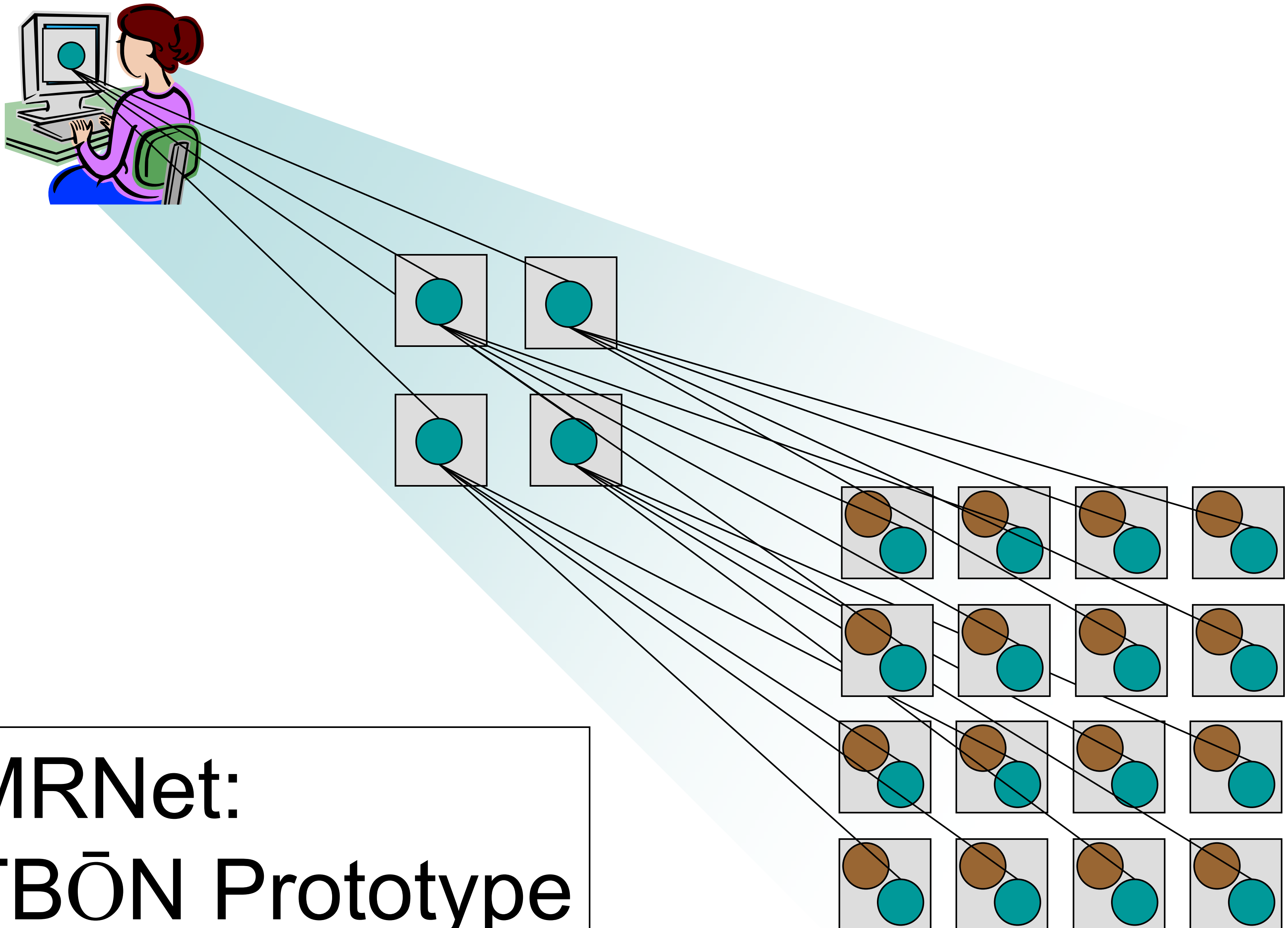
Autonomous Tool Infrastructure

Dorian Arnold
Department of Computer Science
University of New Mexico

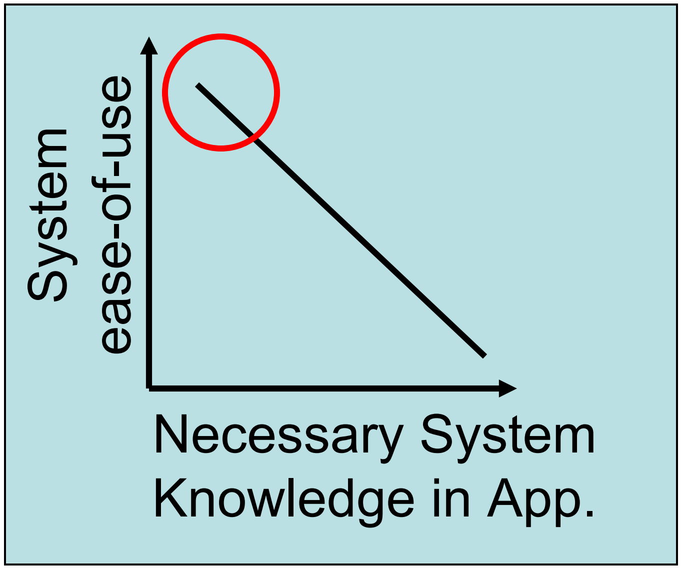
CScADS Petascale Tools Workshop
July 20-24, 2009

The Context: Tree-based Overlay Networks

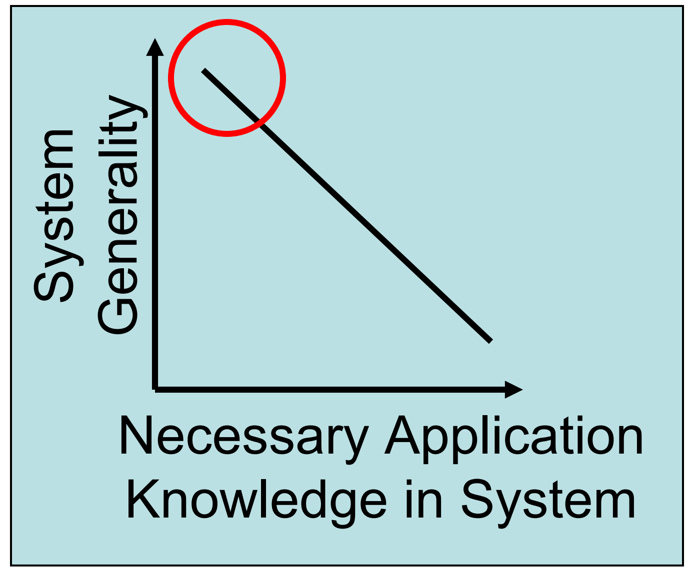


MRNet:
TBŌN Prototype

Problem Statement: Efficient, Scalable Application Performance



1. How much system-specific knowledge does application (developer) need?



2. How much application-specific knowledge does system (developer) need?

3. How far can we get answering "NONE" and "NONE"?

The Approach: An Autonomous TBŌN Infrastructure

TBŌN Autonomy aka the self-* properties:

- Self-configuring

Must maintain scalable, efficient performance!

- Self-optimizing
  - Dynamic TBŌN reconfiguration to improve performance

Research Challenges

- How can we provide a reliable TBŌN service in the presence of failures?
  - Known aliases: "Escape from ~~L.A.~~ Madison", "My dissertation"
- How do we choose the "best" TBŌN topologies?
  - Application load and system characteristics may vary over time
- How can we dynamically improve TBŌN performance?
  - Throughput, latency, resource consumption, startup costs, …
- Can we design a flexible, elegant solution space?

Outline: Past, Present and Future Directions

- Past:
  - TBŌN event/failure detection
  - TBŌN failure recovery
- Present and future
  - TBŌN performance monitoring
  - TBŌN performance modeling
  - Dynamic TBŌN self-configuration and optimization
  - Other issues (as time permits)

Recent MRNet Developments

- Before:
  - MRNet only supported static topologies
  - MRNet did not tolerate any failures
- As of MRNet 2.0 (August ’08)
  - Event detection service
    - Failure detection
    - Dynamic topology configuration
    - New MRNet instantiation protocol
  - State composition for failure recovery

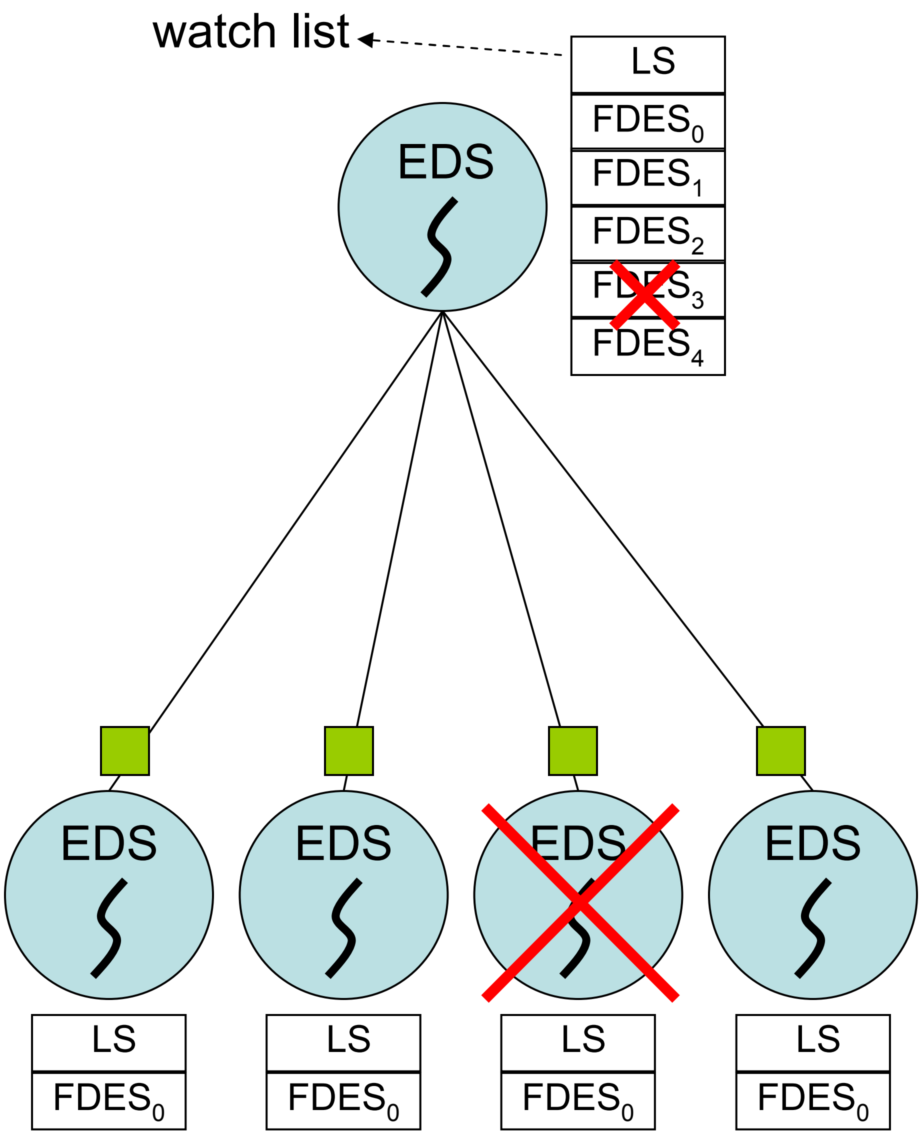
MRNet Event Detection Service

Event Detection Service (EDS) thread

- In each MRNet process
- Passive detection of asynchronous events
  - Failure events for failure detection
  - Connection events for dynamic reconfiguration
- Connection-based (TCP) mechanisms
  - Monitor *watch list* of *event sockets*
    - Listening socket
    - *New Failure Detection Connection* protocol message
    - *New Data Connection* protocol message

Self-monitoring: Detecting Functional Failures

- Each process monitors its peers (parent and children)
- Connect to peer EDS
- Send `New Failure Detection Connection` message
- Add failure detection event sockets to watch list
- Socket error → peer failure



Upon Failure Detection …

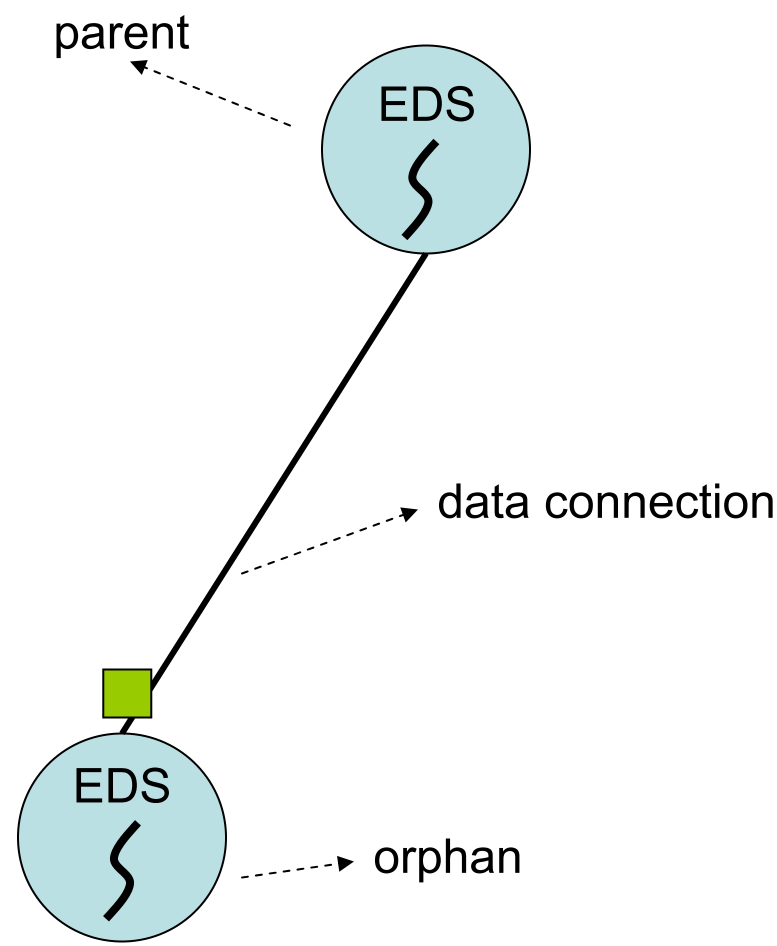
1. The MRNet tree must be reconfigured to reconnect orphaned subtrees

2. MRNet must recover any lost process or channel state (that it can)

MRNet Self-healing: Dynamic (Re)configuration

At initialization or after failures, orphan connect to new parent's EDS

- Send `New Data Connection` protocol message
- Child/parent establish data socket



Self-healing: State Recovery

State Compensation

- Compensate for lost state using inherently redundant information from survivors

- Avoid overhead of explicit data replication

- State Composition
  - Lightweight mechanism
  - Requires associativity, commutativity and idempotence

What’s Next?
“Performance Failures”

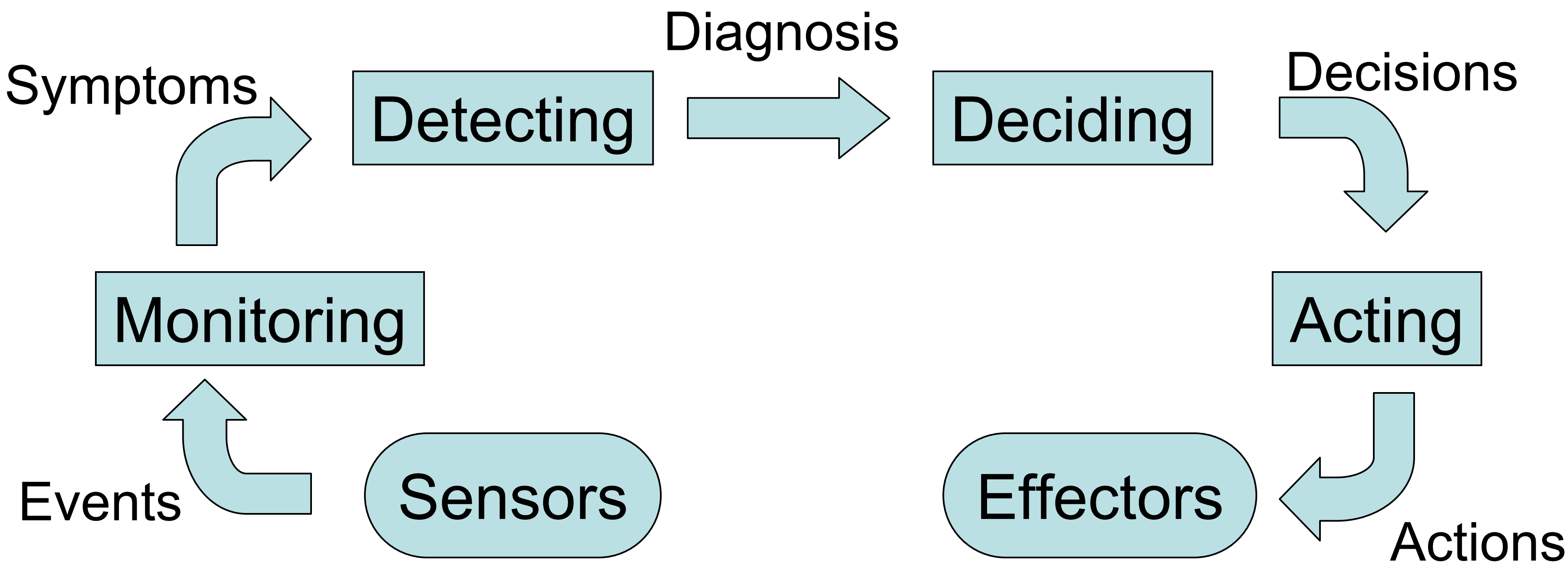
- What is a performance failure?
  - Generally, employing a sub-optimal topology
  - Realizing (much) less than optimal performance
    - Data aggregation latency and throughput
    - Resource under-utilization
    - Imbalanced topologies
  - Per application?
  - Per flow/stream?

Per Flow Topologies

- “best” topology dependent upon
  - Participating end-points
  - Data aggregation operation
  - Application data rate
  - …

- “best” is different for different streams!
  - How can we efficiently enable different topologies for different flows

TBŌN Components for Autonomy



- Low (background) overhead
- Rapid execution
- Must provide more benefits than drawbacks!

Other Issues: Many MRNets or 1

	1 Network per Application	1 Network shared across applications
Pros	Simple Ease-of-deployment No interference between applications	Fast startup Better resource utilization
Cons	Slow startup Poorer resource utilization	More complex Persistent network Help address collocation problems

Other Issues: Native Services

- Separate service dependent from service independent mechanisms
- Improved portability and performance
- Process launching
  - Currently rsh-based
  - Leverage native resource manager or job launcher
    - Might we gain enough startup performance improvement to forego persistent, shared network?
- IPC
  - Currently TCP-based
  - Leverage faster, local communication services

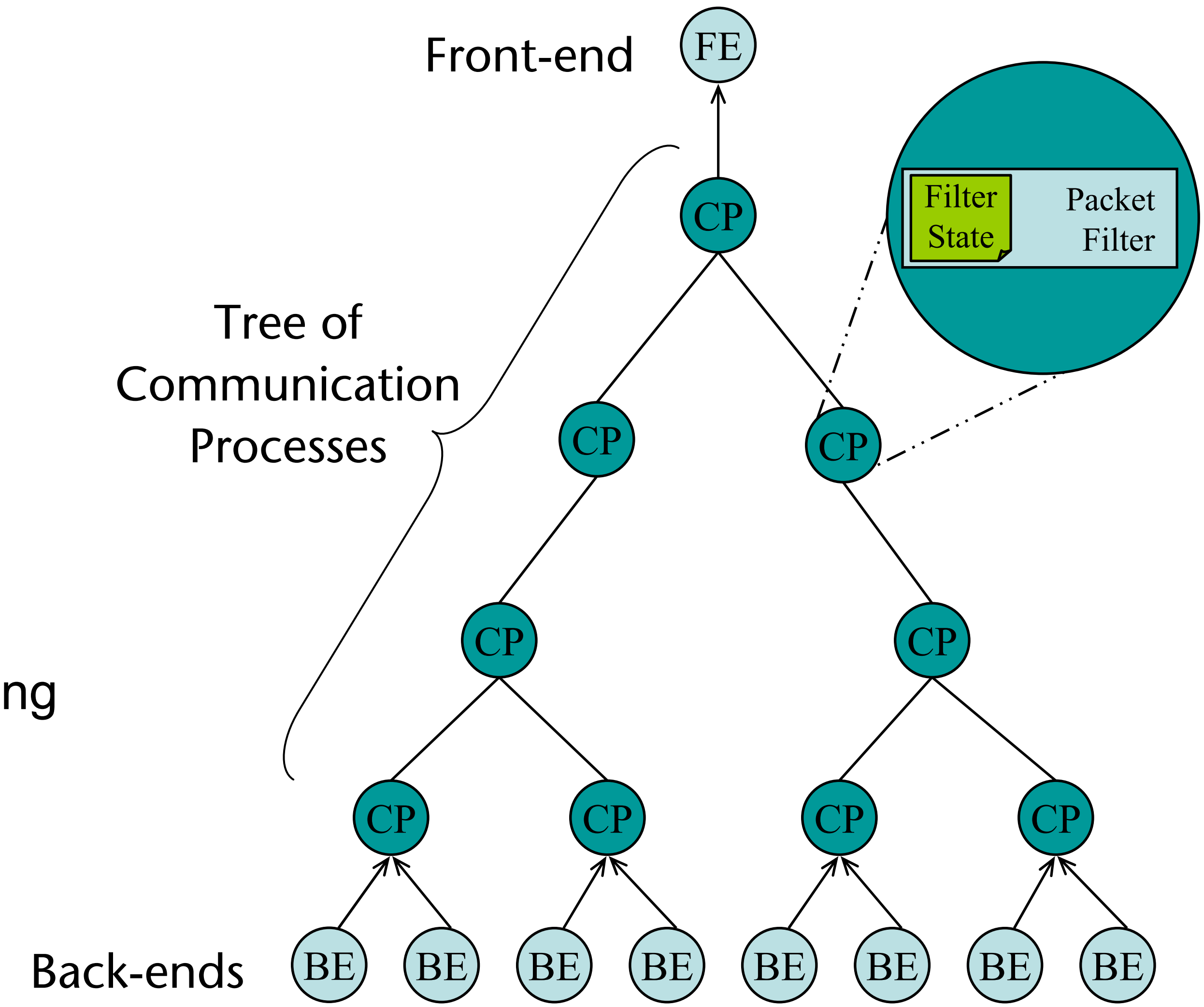
What this means to you

- Simpler, yet better, TBŌN infrastructure
  - Doing (much) more with less!
- We built it, you should come.

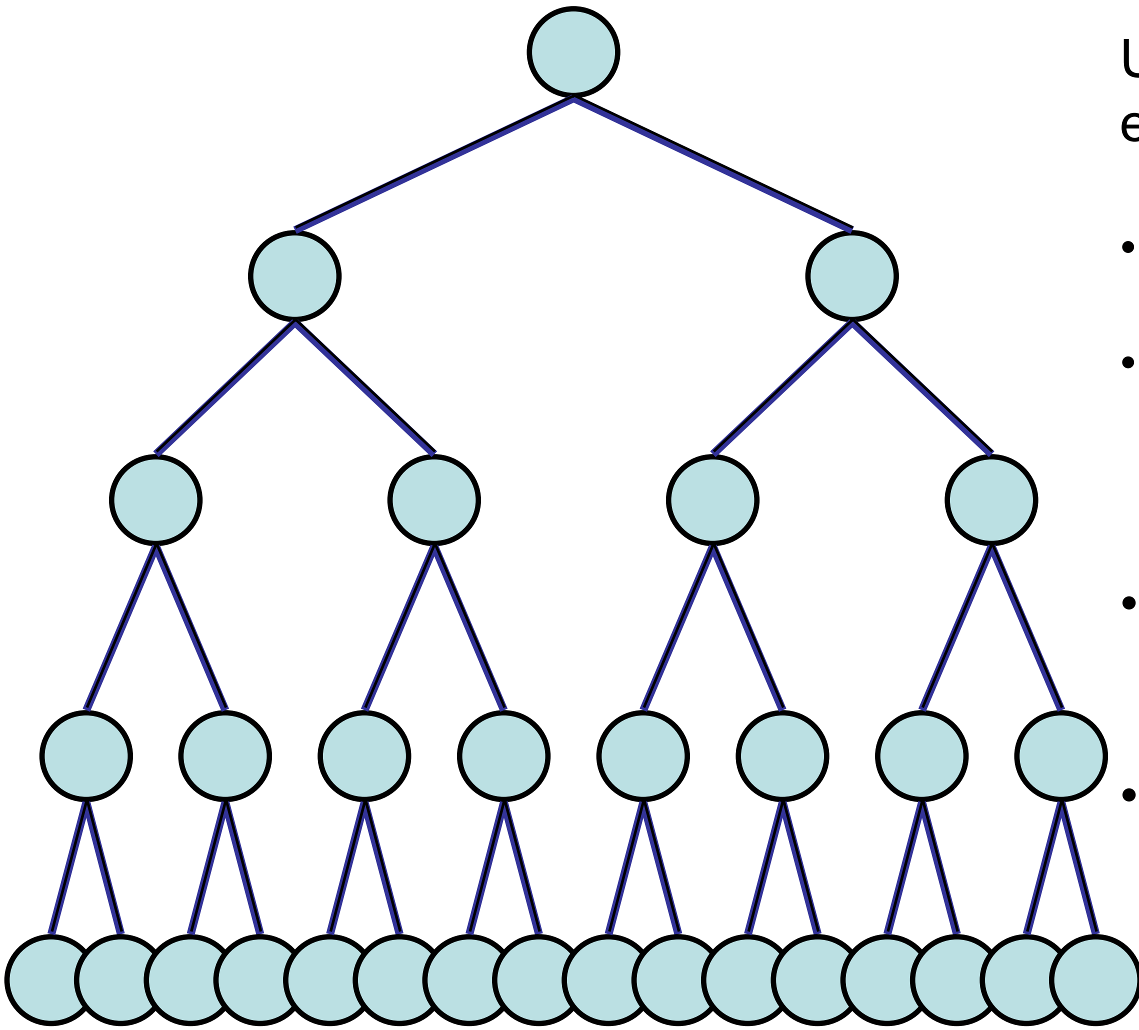
Questions?

MRNet

- Scalable data multicast and aggregation
- Flexible topologies
- User-defined filters
- Trade-off: extra processing nodes for performance



Information Dissemination



Use tree structure for efficient global dissemination

- Failure report:
  - 32 bits: {failed rank}
- Reconfiguration report:
  - 64 bits: {child rank, parent rank}
  - Disconnected subtrees intact

- Disseminating process sends to parent and children

- Receiving processes send to peers other than source

State Composition Interface

```
outPacket get_FilterState( void ** inFilterState );
```

- Inputs pointer reference to stream's filter state
- Outputs "packetized" version of filter state

```
int load_FilterState( const char * inSharedObject
                      const char * inFilterFunction );
```

- Used to dynamically load new filter functions
- Also queries for `get_FilterState` routine
  - If found, filter is *recoverable*