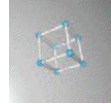




ExScal Backbone Network Architecture



Dependable Distributed and Networked Systems, The Ohio State University

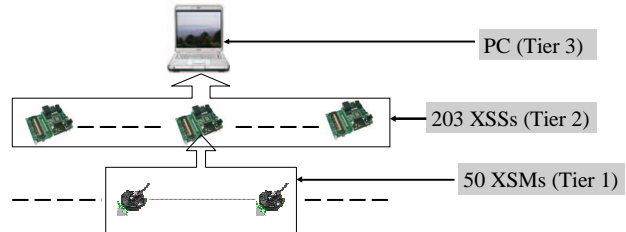
<http://cast.cse.ohio-state.edu/exscal>

Introduction: Extreme Scaling of a A Line in the Sand

ExScal Specifications Imply a Backbone Network (Tier 2)

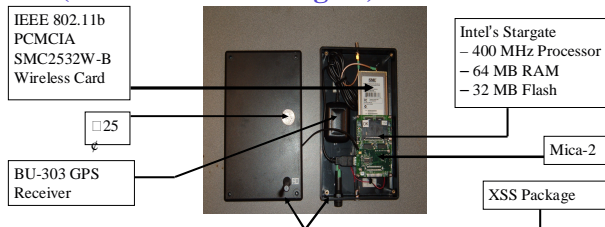
- **System**
A distributed system of ~1000 sensor nodes spread across 1.26 Km X 300m
- **Real Time Behavior**
Detection, classification, and tracking at the base station in real time
- **Low Overhead**
Low cost, power efficient, robust, accurate, easily deployable, and self configurable system

Network Hierarchy

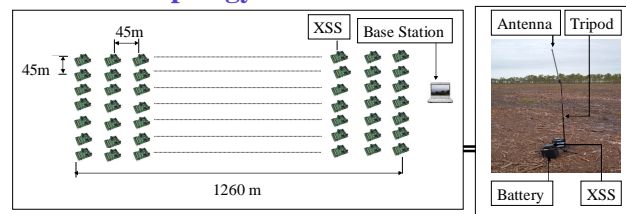


Tier 2 Anatomy: Hardware and Layout of XSS Network Deployment

XSS (Extreme Scale Stargate)



Network Topology



Problem Description: Fault Tolerant Services for the Tier 2

Specifications of Middleware Services:

- **Initialization of XSSs**
 - Initialize processes on all XSSs and collect the geographic locations of all XSSs at the base station
 - Communicate reliably and (energy) efficiently packets, each of size up to 1 Kbyte, to all XSSs and collect a packet of size up to 32 bytes from each of XSSs
- **Convergecast**
 - Collect data and status from all XSSs e.g. intruder event detection, tier-1 reprogramming feedback, tier-1 and tier-2 management feedback
 - Reliable and energy efficient delivery of an event detection message from any XSS to the base station within 6 seconds
- **Broadcast**
 - Disseminate bulk of data to all XSSs e.g. reprogramming of the XSMs, tier-1 and tier-2 management queries
 - Reliable and energy efficient transmission of a file of size up to 200 Kbytes to all XSSs

- **Management**
 - Monitor processes on XSSs e.g. CPU usage, disk usage
 - Configure services running on XSSs e.g. change transmission power level
 - Invoke Deluge, SNMS queries and collect the result of the queries

Fault Model:

- Crash of one or more user level processes on a XSS
- Fail stop of a XSS
- Change of location for a XSS

Challenges:

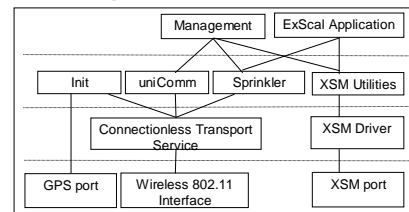
- **Initialization of XSSs**
 - No assumption about the topology of the network
- **Convergecast**
 - Estimate the qualities of the links using only data traffic
- **Broadcast**
 - Avoid collisions among messages while broadcasting without timesync

Solution: Tier 2 Network Protocol Suite and Management

Protocols:

- **Init**
 - Uses controlled flooding to construct a distributed tree over the network
- **uniComm**
 - Chooses route based on beacon-free in-situ link estimation
- **Sprinkler**
 - Constructs a CDS (connected dominating set) and a corresponding packet forwarding schedule for the nodes in CDS to minimize the number of transmissions
 - **Streaming Phase:** Uses explicit acknowledgements, piggybacked on the data packets, to reliably communicate packets to all the nodes in CDS
 - **Recovery Phase:** Reliably communicates packets to all the non dominating nodes using pull model and unicast transmission
- **Management**
 - Uses Sprinkler to broadcast the queries to all XSSs and the responses from all XSSs are collected at the base station using the UniComm
 - Uses timer to monitor the spawned processes

Architecture Diagram:



Performance:

- **Init**
 - Average latency of **6.5** seconds with **100%** reliability
- **uniComm**
 - Average end-to-end latency is **0.25** seconds
- **Sprinkler**
 - Minimum Latency to transmit a **100K**bytes file to all XSSs is **6** seconds