Exscal

Tier 2 Architecture

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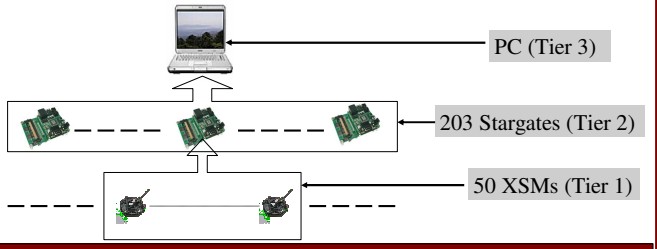
http://cast.cse.ohio-state.edu/exscal

Introduction: Extreme Scaling of a *A Line in the Sand*

Exscal Specifications Imply a Backbone Network

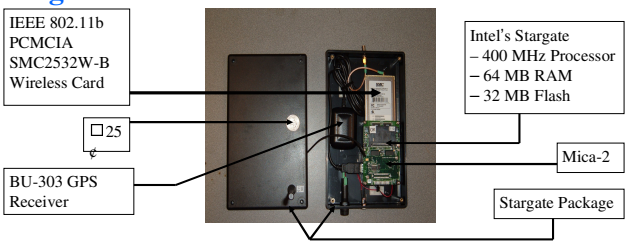
- **System**
  A distributed system of ~1000 sensor nodes spread across 1.3 Km X 300m
- **Real Time Behavior**
  Detection, classification, and tracking at the base station in real time
- **Low Overhead**
  Low cost, power efficient, robust, accurate, easily deployable, and self configurable system

Network Hierarchy

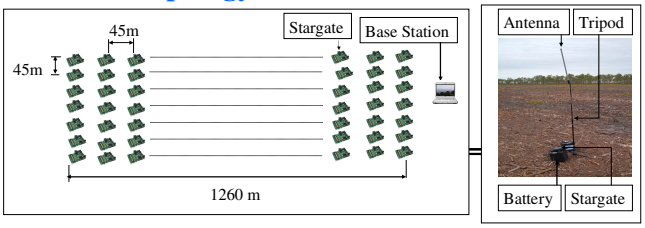


Tier 2 Anatomy: Hardware and Layout of Stargate Network Deployment

Stargate



Network Topology



Problem Description: Fault Tolerant Services for the Tier 2

Specifications of Middleware Services:

- **Initialization of Stargates**
  - Initialize processes on all stargates and collect the geograhic locations of all stargates at the base station
  - Communicate reliably and (energy) efficiently packets, each of size up to 1 Kbyte, to all stargates and collect a packet of size up to 32 bytes from each of stargates
- **Convergecast**
  - Collect data and status from all stargates 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 stargate to the base station within 6 seconds
- **Broadcast**
  - Disseminate bulk of data to all stargates 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 stargates
- **Management**
  - Monitor processes on stargates e.g. CPU usage, disk usage
  - Configure services running on stargates 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 stargate
- Fail stop of a stargate
- Change of location for a stargate

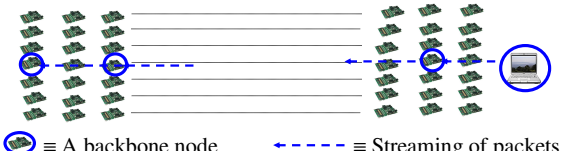
Challenges:

- **Initialization of Stargates**
  - 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 Monitoring

Protocols:

- **Initid**
  - 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 backbone and a corresponding packet forwarding schedule for the backbone nodes to minimize the number of transmissions
  - **Streaming Phase**: Uses explicit acknowledgements, piggybacked on the data packets, to reliably communicate packets to all the nodes on the backbone



  - **Recovery Phase**: Reliably communicates packets to all the non-backbone nodes using pull model and unicast transmission
- **T1mgmtd**
  - Uses Sprinkler to broadcast the queries to all stargates and the responses from all stargates are collected at the base station using the UniComm
  - Uses timer to monitor the spawned processes

Performance:

- **Initid**
  - Average latency of **6.5** seconds with **90%** reliability
- **UniComm**
  - Average end-to-end latency is **0.25** seconds
- **Sprinkler**
  - Latency to transmit a **100**Kbytes file to all stargates is **12.083702** seconds
  - Transmits **7%** of messages as compared to randomized flooding

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