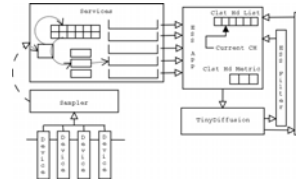
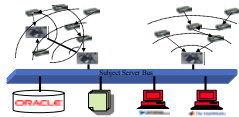


# The Extensible Sensing System

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 CENS – <http://www.cens.ucla.edu/>

## Overview: How the ESS Enhances Systems

- The goals of the *Extensible Sensing System (ESS)* are:
  - Provide taskable and triggered data extraction in the presence of failures
  - Support network monitoring and manageability
  - Serve as the testbed for one of the World's largest sensor network deployments
- Within the ESS there are 2 classes of nodes:
  - Sensor nodes provide data and perform the bulk of the application logic
  - Concentrators provide highly available and higher power resources such as network backbone access
- Data is multicast over the Internet through a *publish-and-subscribe* bus system called the *Subject Servers* to clients such as databases, GUIs, and other data analysis tools.



- The ESS is deployed at the James Reserve to facilitate micro-climate analyses using:
  - Mica2 motes equipped with a specialized Sensor Interface Board
  - iPAQ nodes acting as Concentrators
- The sensor system is decomposed into logical components
  - TinyDiffusion* for data transport
  - ESS application and diffusion-filters for management
  - A Services component for data manipulation and caching
  - A Sampler for device management and interface.

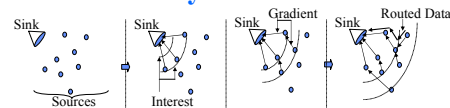
## System Architecture: Components of the System

### Sensor Interface Board

- A general framework for attaching multiple instances and different types of sensors
  - ADC true 12bit
  - High gain differential channels
  - Digital Input (Interrupt driven)
  - Digital Outputs
  - Counter, frequency
  - Relay output
  - On board voltage, temperature and humidity
- Flexible sampling rate*
- Configurable for different translation functions per channel based on the sensors that has been attached
- Tested with different sensor types.
  - <http://www.cens.ucla.edu/~mhr/daq/>

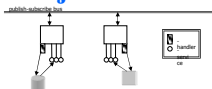


### TinyDiffusion



- ESS uses a variant of Directed Diffusion called "*One Phase Pull*" (Heidemann-Silva) on the sensor nodes
- Interest packets sent by sinks are flooded
- Data is sent back by each source along a single chosen gradient to a single sink at a time
- One Phase Pull uses symmetric links:
  - Achieved using the neighbor link characterization module
  - Link loss rate is assessed using heart-beat packets
  - EWMA* used for loss calculation and *Hysteresis* for "good link" selection

### Subject Servers



- The goals of the Subject Servers
  - Data dissemination to arbitrary set of clients
  - Internet connectivity for remote access
  - Transport-independent API*
- Methodology
  - Data from sensors, GUIs, etc. is published
  - Clients subscribe to data they want

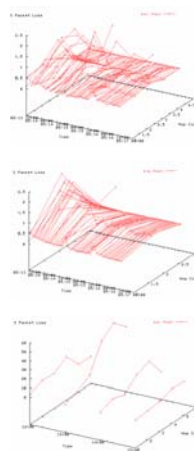
### User Interface



- The GUI acts as a Subject Server client
  - Requests for data are passed to the bus
  - The bus returns the response from the database server
  - Posts results in a *dynamically generated web document*

### ESS Deployment

- Researchers have been able to study a variety of network characteristics in this real-world in-situ deployment
- Average system loss rates have been analyzed over fixed intervals and related to nodes of various: average, minimum, and maximum hop counts
- Additional nodes have been deployed to augment the persistent ESS topology in order to study effects such as
  - Loss experienced by nodes that are introduced with less ground clearance.
  - The effects of increased network congestion
  - The effects of increased hop counts



### Future Work

- The ESS has proven to be a very large step forward for real-World sensor network deployments.
- The system has been designed to easily incorporate:
  - In-network processing*
  - In-network triggering*
  - Remote sensor tasking
  - Remote network monitoring
  - Support 1451 *plug-and-play* standard
- As the supported set of operations grows, the ESS deployment will become a valuable asset for:
  - Supporting natural-science applications
  - Deploying experimental network applications
- Immediate potential for ESS:
  - Soil arrays for contaminant monitoring and precision agriculture
  - Canopy instrumentation
  - Structural monitoring
  - Macro-programming*