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Center for Embedded Networked Sensing

System Support for Coordinated Imaging for Sensor Networks

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Mote Herding: The next step in Tiered Systems

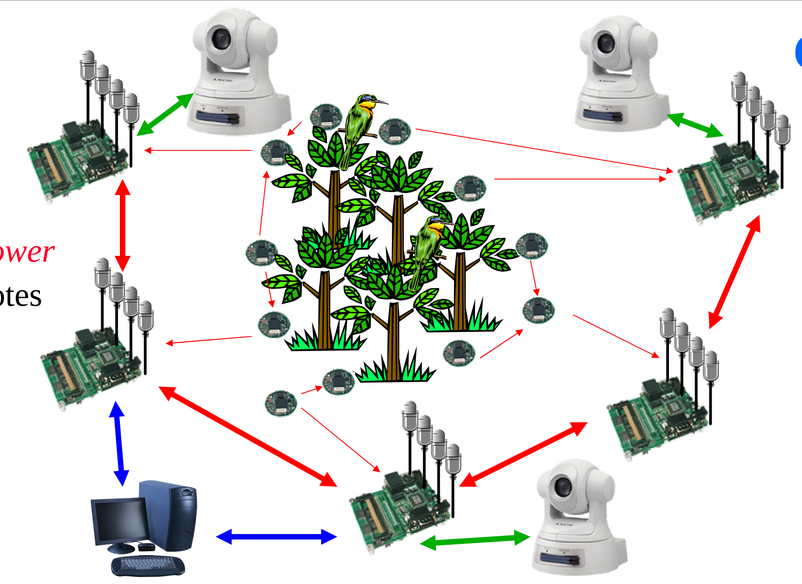
Mote Herding

Tiered systems: Collections of *motes* and *microservers* working together

- **Motes** help achieve the desired *spatial density*
- **Microservers** increase the system's *processing power*
- **Efficient** and cohesive *interoperation* between motes and microservers

Why not **statically** assign motes to stargates?

- Network and environmental *dynamics*
- Dealing with *failures*
- Needs to be done every time



Coordinated Triggered Imaging

Traditional imaging systems: 24/7 monitoring

- **Constant** human *supervision*
- **Large** amount of *data* that has to be processed *manually*
- **Significant** power consumption
- The system should only take a picture when *required* to do so

Why not just 'a sensor triggers a camera' ?

- Nontrivial camera selection based on *latency*, *reaction time*, *orientation*
- Significant system *heterogeneity*

Mote herding is a new *design approach* and **coordinated triggered imaging** is an *example application* illustrating this new approach

System and Design Issues

Mote Herding is…

- **Registration Protocol**
  - Network registration: Binding between the *mote* and its *herder*
  - Motes try to *always* be *attached* to a herder
  - Logical registration: Binding between the *sensor* and the *actuator*
  - Network and Logical registration in general don't overlap
- **Microserver Information Sharing**
  - Allows microservers to present a *high quality global state view* to the application due to increased *spatial* and *temporal resolution*
  - Enables seamless data flow from *sensors* to *actuators* with herders acting as proxies
  - System state exchange allows for *resource handoff*

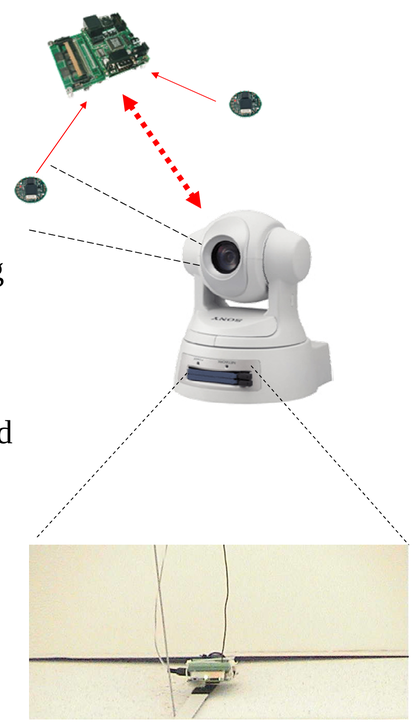
Mote Herding enables…

- **Coordinated Triggered Imaging**
  - Associates mote *locations* and camera *fields of view*
  - Seamless *data flow* from a collection of *motes* to a collection of *cameras*
  - Resource location: find the most *appropriate* camera in terms of *coverage*, *reaction* time and *orientation*
  - Resource contention**:** camera *load balancing*
- **System Health Monitoring**
  - Monitor the status of all system components: *stargates*, *motes* and *actuators*
  - Take appropriate action if necessary: *hand off* motes to different herders
- **Custody Transfer and Storage Management**
  - Microserver *storage capacity* allows them to act as *custodians* in a particular custody hierarchy

Preliminary Implementation Details

Demo Setup

- **Hardware**
  - Sony RZ30N pan-tilt-zoom *steerable* camera
  - A *stargate* connected to a camera via *ethernet*
  - A mica2 mote attached to the stargate acting as a *motenic*
  - A pair of mica2 motes with *PIR sensors* acting as the triggering input
- **System goal**
  - When a mote's PIR sensor detects activity, steer the camera and take a *picture* of the mote's *surrounding area*
- **Mote Herding**
  - The *stargate* is the *herder* while the *motes* are the *herd*
  - Association: how does the *stargate* know *where* to point the camera?



Application Setup

- **Mote software**
  - **Data transport** is achieved using a diffusion like *multihop tree* protocol with the sink running on the stargate
  - **Interfaces** to the stargate part of the system are provided through *EmTOS / motenic*
  - **Data** sent from a mote to the sink after a PIR sensor *interrupt* occurs
- **Controlling application**
  - Binds mote *locations* to camera *orientation* and *zoom*
  - Issues *steering commands* to the camera driver based on *data* coming to the *multihop sink*
  - Receives *image data* through a *sensor client*

Camera control

- **Camera driver**
  - Fully *integrated* with the *EmStar framework*
  - Uses *cURL* in *asynchronous* mode to handle HTTP requests and replies
  - Provides *status devices* that contain information on all camera components and configurations
  - Provides *query devices* for all actuation commands
  - Can be controlled from the *command line* or through a *query device client*
  - Imaging provided through a *sensor device* as well as a jpeg file
  - Supports *non-blocking* operations
  - Supports *multiple concurrent requests* through a *serialization scheduler*

Conclusions and future work

- **Mote herding** is a *set of tools and services* that act as a middleware component
  - Enables *seamless interoperation* of motes and stargates
  - Masks *resource heterogeneity* under common *abstractions*
  - Provides *higher-layer* services that applications can use
- **Future work**: build a complete coordinated triggered imaging system that utilizes mote herding and *extend* the concept to *other classes* of applications