An Integrated Instrumentation Architecture for NGI Applications

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http://www-pablo.cs.uiuc.edu/Project/Pablo/NGIOverview.htm

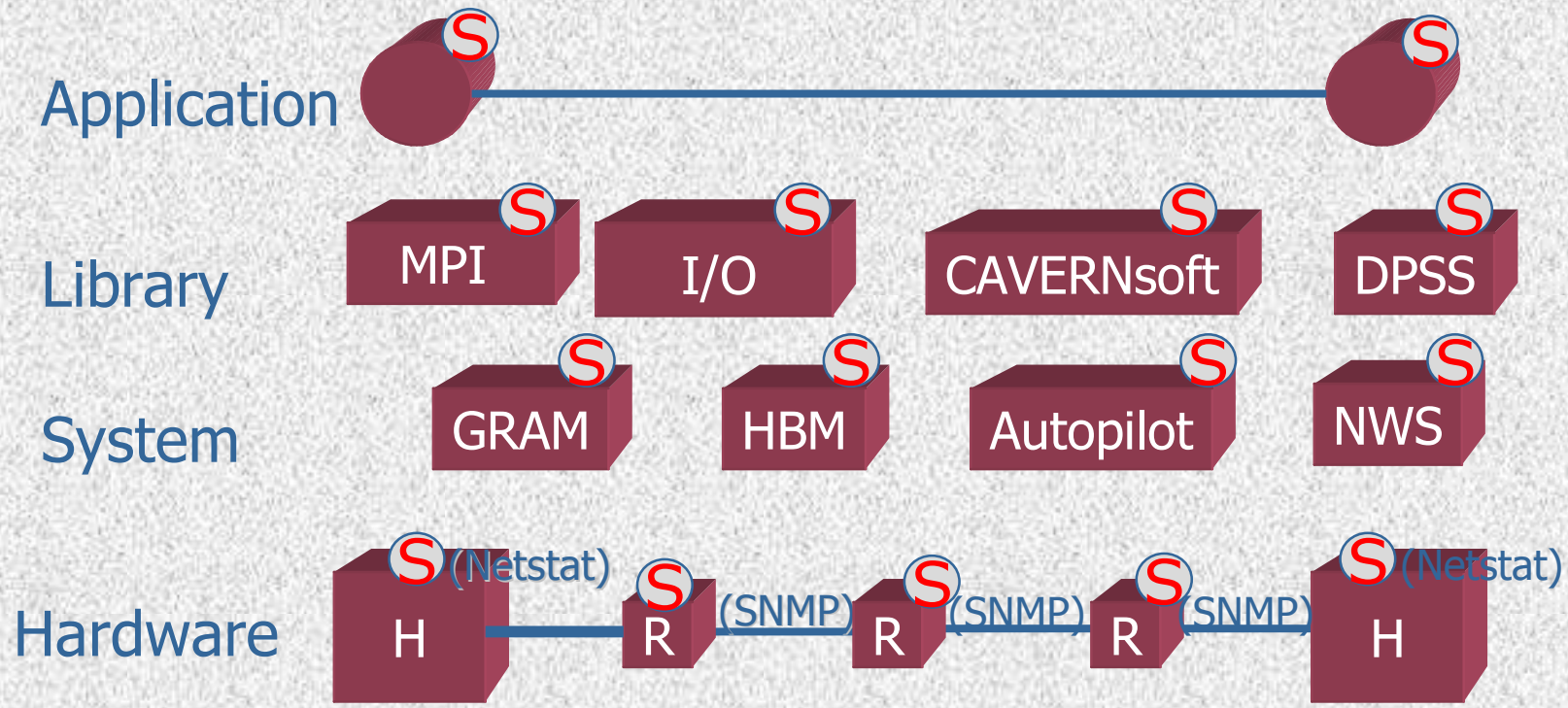
Project Goals

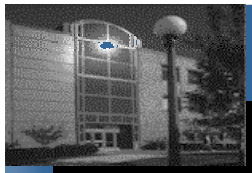
- Produce uniform mechanisms
  - instrumentation and event notification
    - » qualitative and quantitative data
  - dynamic adaptation
- Catalyze development of both network-aware middleware and sophisticated network-aware applications

"A Uniform Instrumentation, Event, and Adaptation Framework for Network-Aware Middleware and Advanced Network Applications"

Multilevel Sensor Example

- Multilevel data needed for analysis
  - possible performance problems at all levels
  - diverse data sources; *no standard access mechanisms*
  - *no standard publication or discovery techniques*

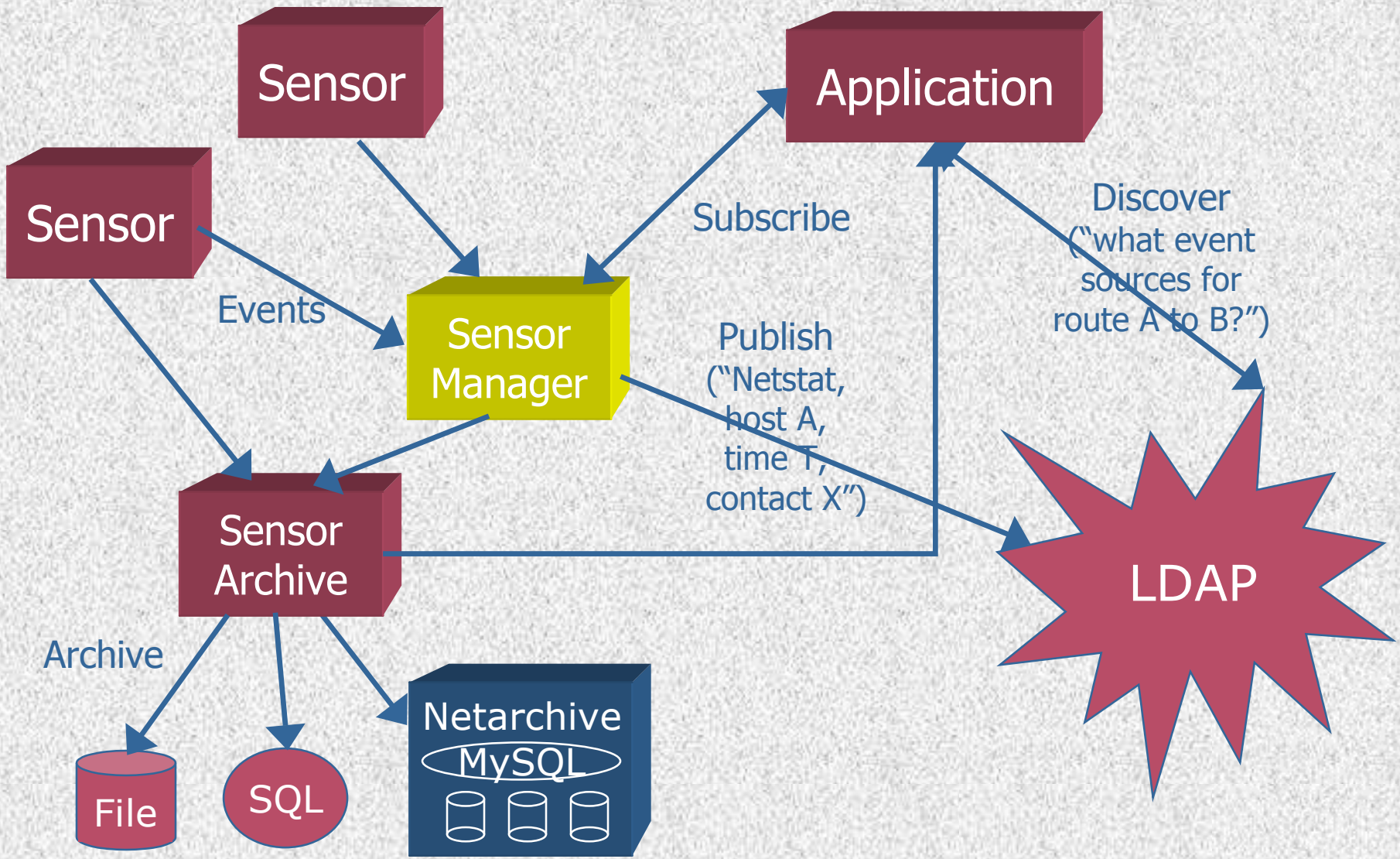




Key Technical Innovations

- Sensor mechanisms
  - creation, publication, discovery and access
- Synthesis and analysis techniques
  - extraction of qualitative behavior and trends
- Adaptation techniques
  - exploitation of sensor data
  - optimization of middleware and applications
- Implementation mechanism
  - *Globus/Autopilot/Netlogger integration*

Instrumentation Architecture



Project Sensor Approach

- Directory service (LDAP)
  - publish: source, type, contact [online, archive]
  - discover: "find all event sources of type X"
- Autopilot sensor manager extensions
  - publication, subscription, and archiving
- Standard data formats
  - LBL Netlogger, Illinois SDDF, and XML
    - » standard converters (e.g., SDDF to XML, Netlogger to SDDF)
- Relational database archive
  - publicly available SQL implementation
- Standard sensor set integration

Sensor Publication and Discovery

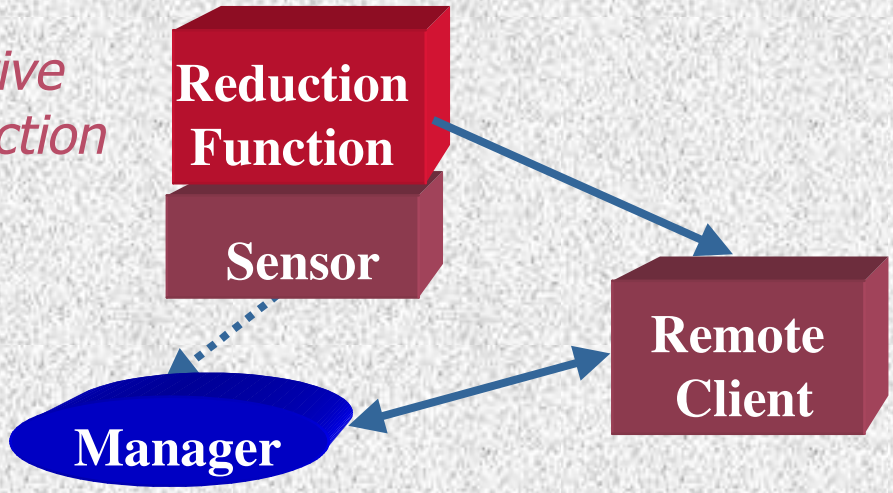
- Globus LDAP MDS
  - Metacomputing Directory Service (MDS)
  - scalable, global infrastructure for publishing and discovering sensor managers
- Approach
  - sensors send attributes to sensor manager
  - sensor manager publishes availability via LDAP
  - clients discover sensor managers from LDAP
    - » then directly subscribe to current or archived sensor data
- Netlogd/Globus/Autopilot extension/integration

Archiving Sensor Streams

- SQL database
  - each event as a record in an SQL database
    - » offers rich query support
- Netarchive
  - each event stored in a file with SQL index
    - » offers performance and scale
- We will explore SQL databases
  - emphasize sensor data reduction at sources
  - reduce event data volume for archiving
  - prototype XML to SQL interface operational

Standard Sensors: Autopilot Base

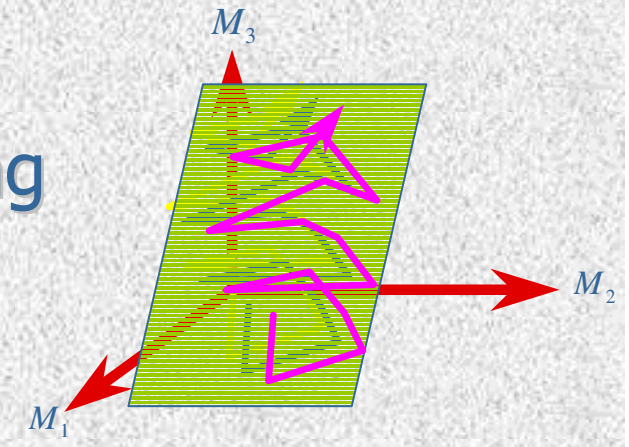
Quantitative and *qualitative*
data reduction and prediction



- Quantitative sensors
  - application
    - » software and hardware
  - library
    - » MPI, I/O, HDF, and MPI-IO
  - daemon
    - » network & system statistics
- Software
  - » Netlogger, Globus, Autopilot, …
- Two aspects
  - *quantitative* resource use
    - » numerical measurements
  - *qualitative* request patterns
    - » behavioral classification

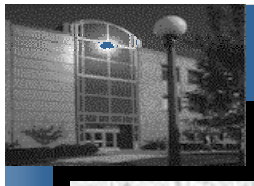
Data Reduction Techniques

- Challenge: reduce sensor data volume
  - many metrics and concurrent activities
- Statistical clustering
  - based on square error clustering
  - reduces the number of points
- Projection pursuit
  - based on principal component analysis
  - identifies "important" metrics
- Result
  - relevant metrics from relevant sites

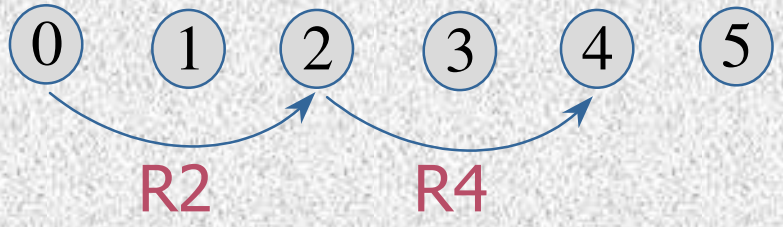


Classification and Prediction

- Two axes for classification and prediction
  - spatial (where) and temporal (when)
- Neural network classification (ANNs)
  - accepts quantitative sensor data
  - generates qualitative classification
    - » regular, irregular, large, small, bursty, slow, fast …
- Hidden Markov models (HMMs)
  - learns access probability distribution functions
  - recognizes non-qualitative patterns
- ARIMA time series
  - learns temporal behavior and predicts future patterns

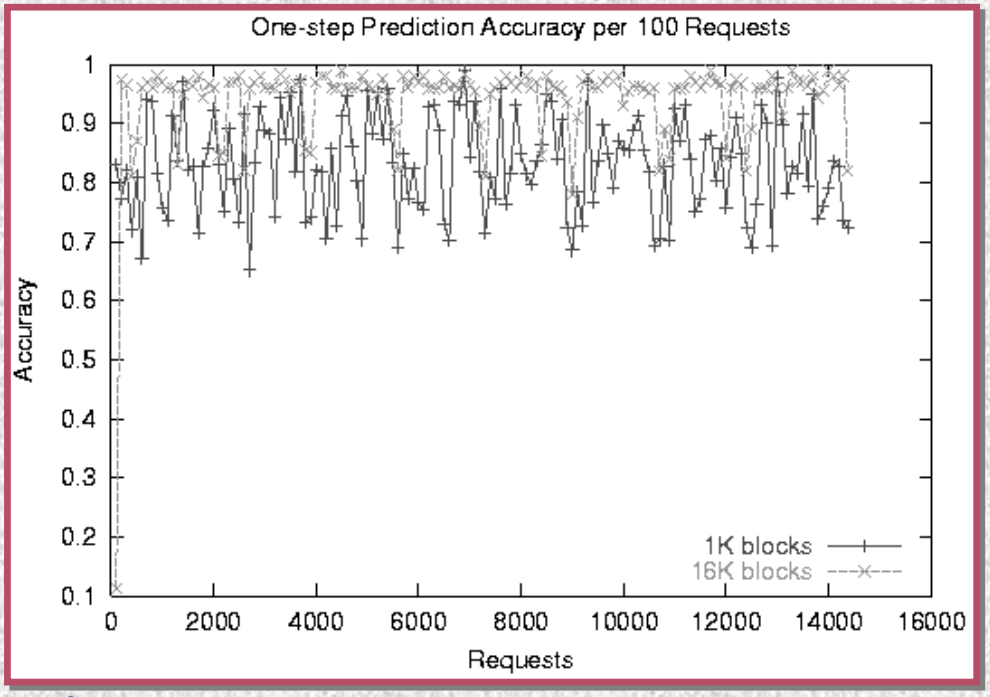


LLNL ALE3D HMM I/O Prediction



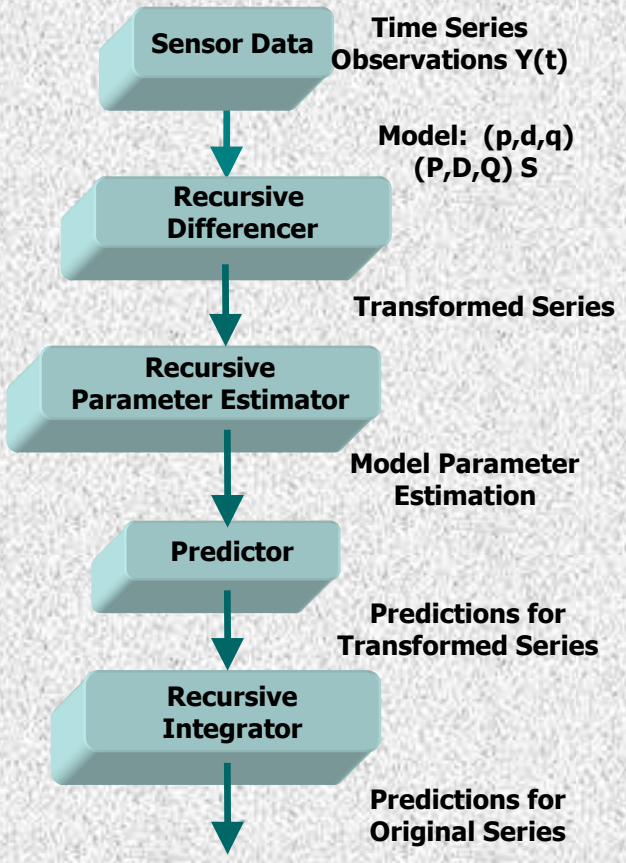
Example:
Read only strided

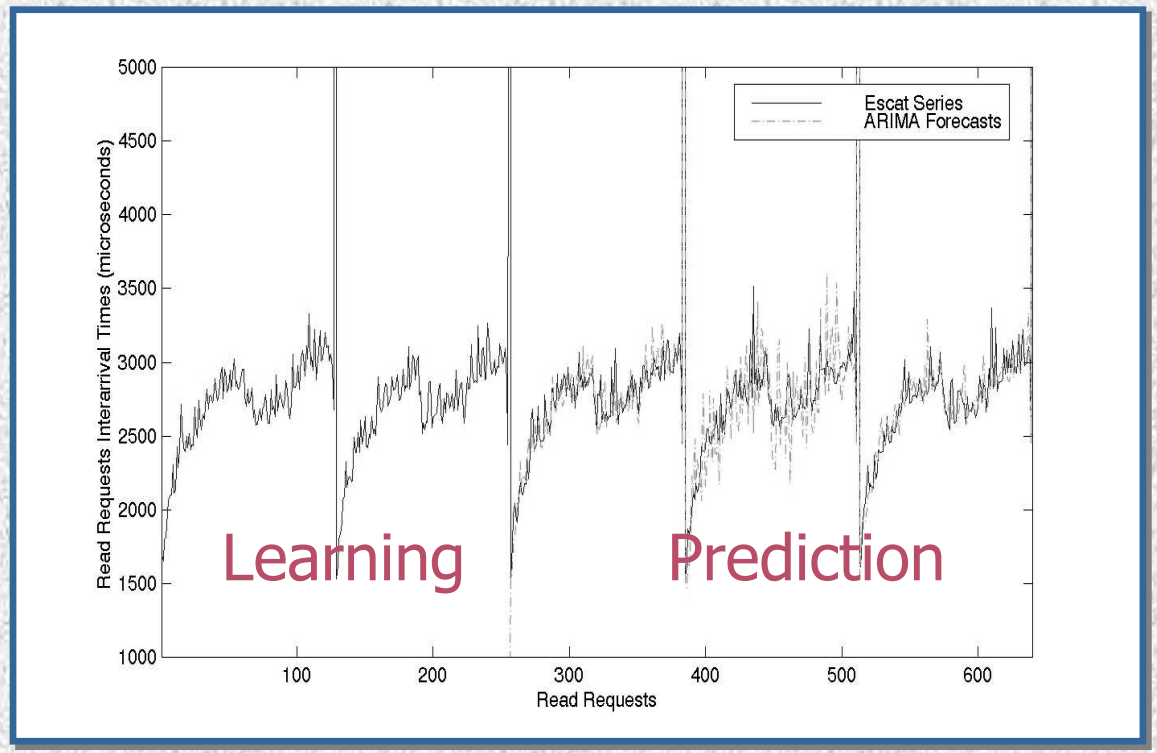
- Prediction
  - I/O block accesses
  - high accuracy
- Other domains
  - network traffic
  - system utilization



Additional funding from DOE ASCI and NSF

Caltech ESCAT ARIMA Predictions





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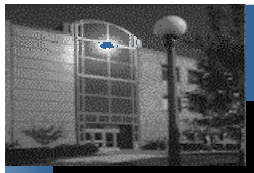
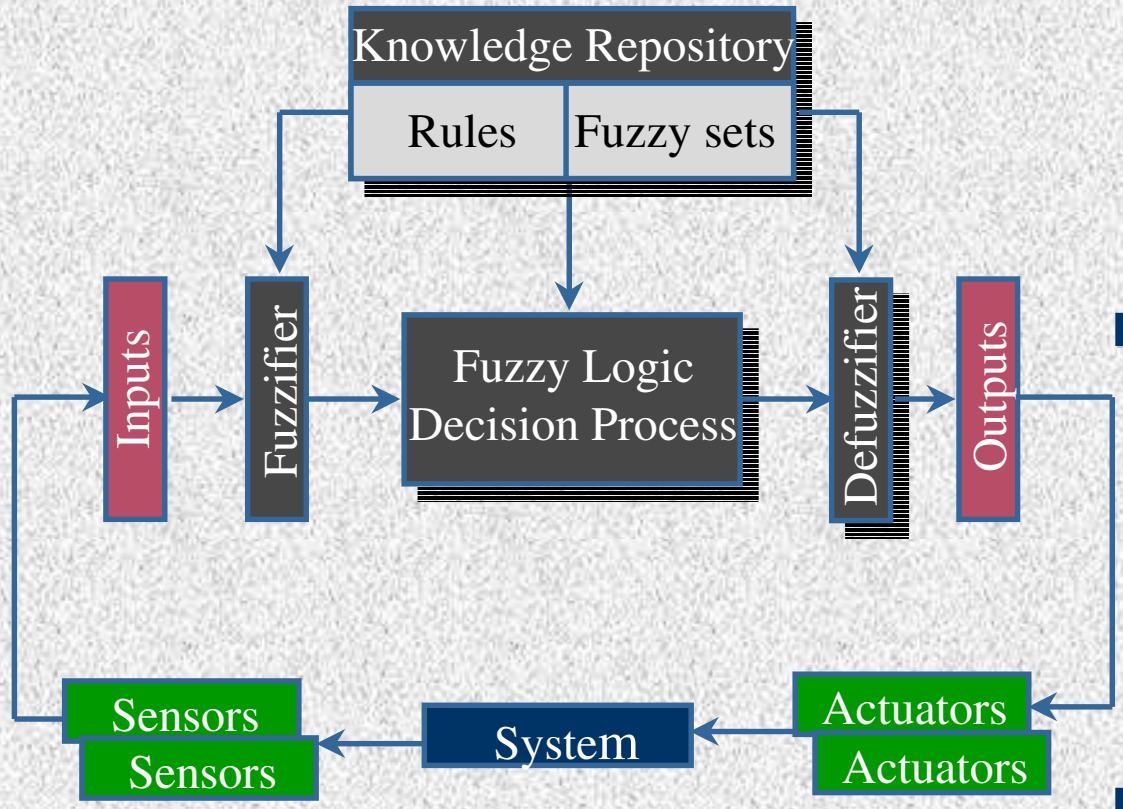


Middleware Adaptation Process



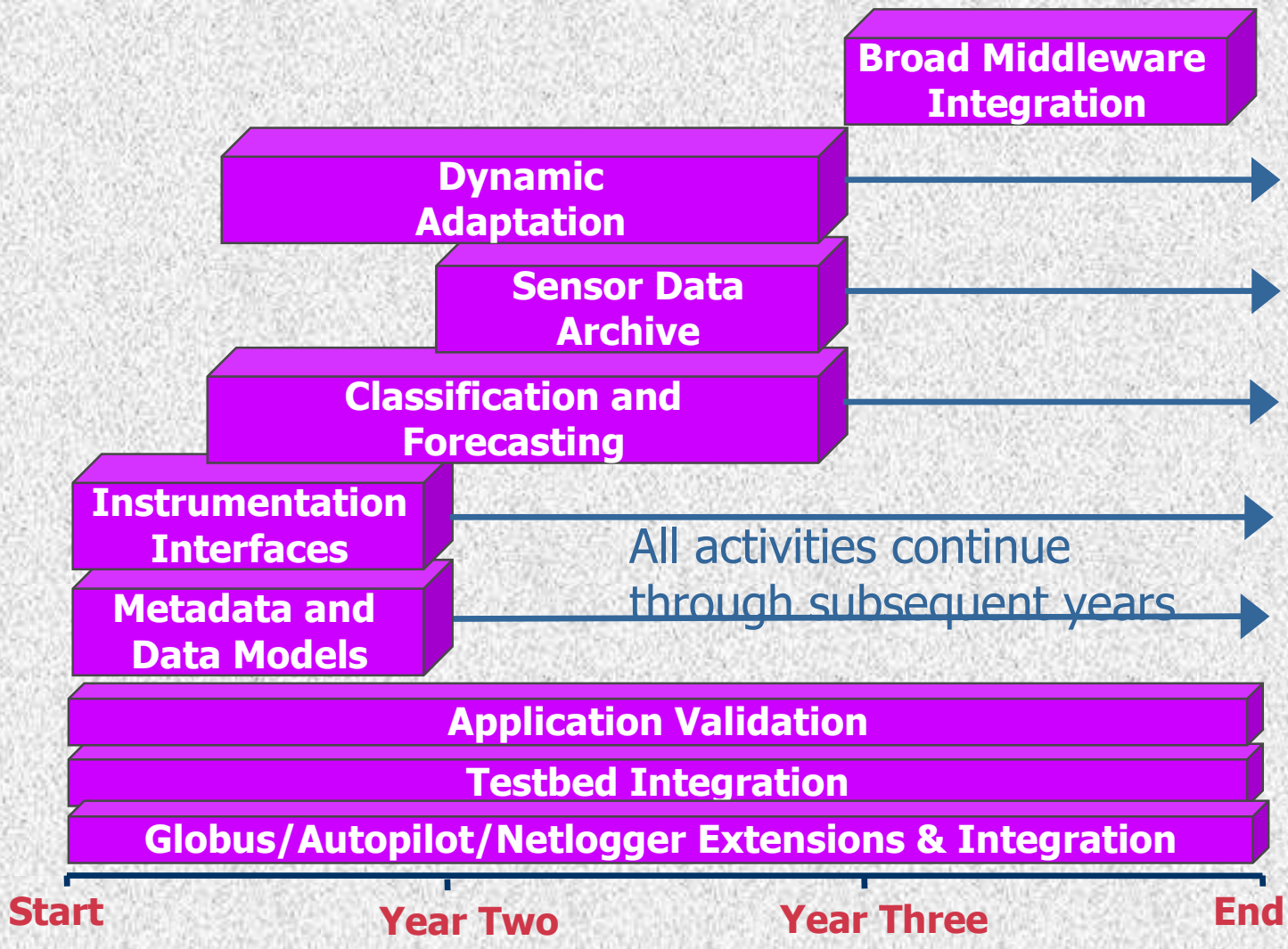
Based on Autopilot toolkit

- Fuzzy rule base
  - qualitative behaviors
  - retargetable
- Catastrophe theory
  - rule optimization
  - transitions
  - hysteresis
  - near-optimal control
- *Result*
  - *software control toolkit*

Security

- Grid Security Infrastructure (GSI)
  - will be used throughout
    - » "manager M accepts only streams from sensors of user U"
    - » "manager N only publishes streams to clients of users A, B, C"
- As a first step
  - LBNL augmented Netlogger C client with GSI

Initial Applications

- Replica creation in "data grid" applications
  - online and historical instrumentation
    - » large data transfers (application, library, and network)
  - DPSS and Globus-IO (with LBNL)
  - application-level selection of replicas
    - » based on sensor information
- MPI video streaming (Karonis and Papka)

Project Timeline