

# In-Network Query Processing on Heterogeneous Hardware

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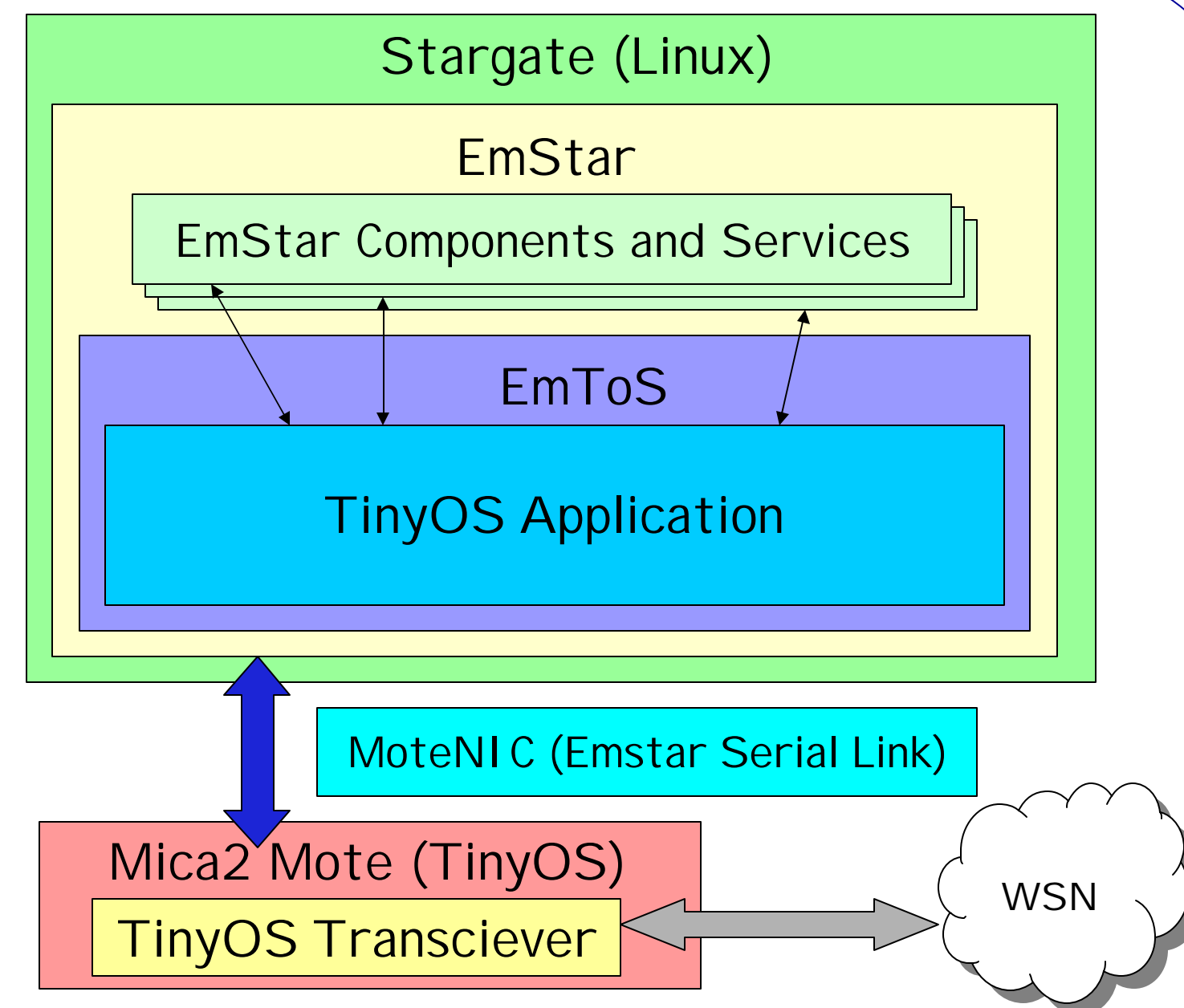
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## EmTOS

- EmTOS is the bridge between TinyOS and EmStar
- Emulates TinyOS API
- Runs unmodified NesC code
- TinyOS apps can interact with EmStar components and the entire Linux environment

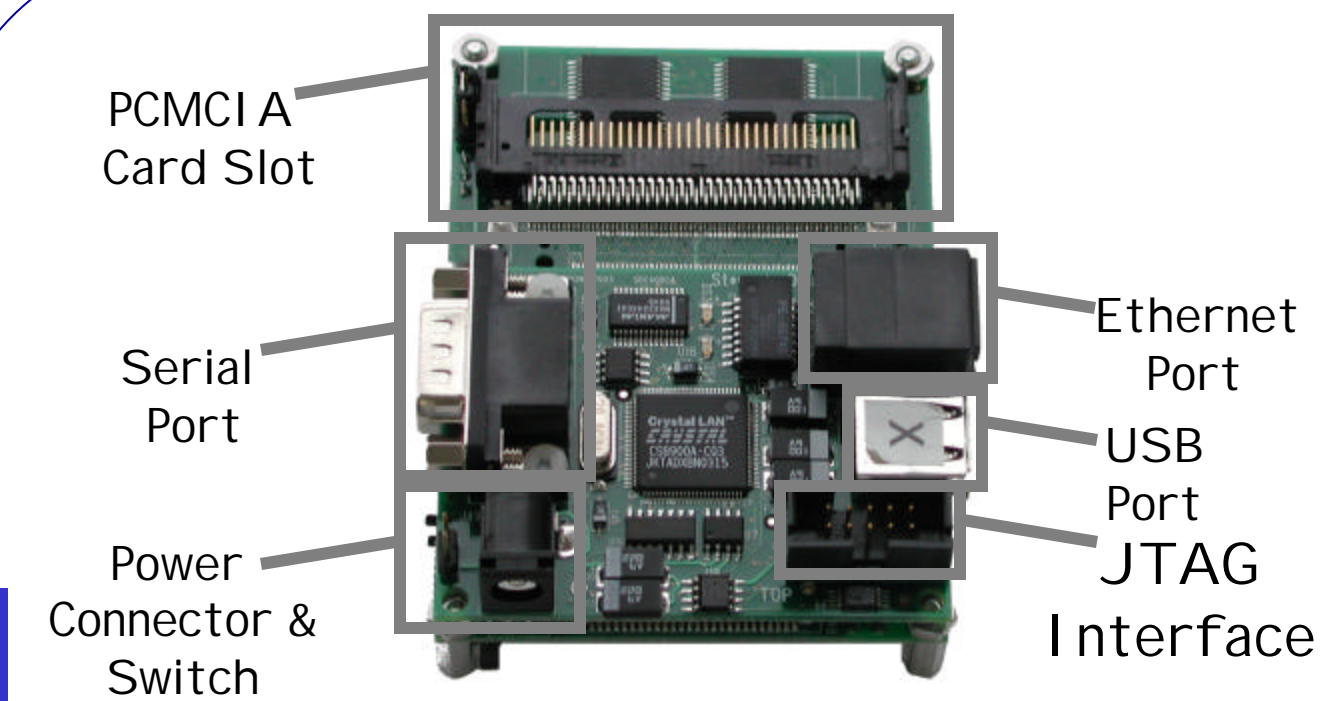
## EmStar

- Distributed debugging and development environment for Linux
  - Targeted to sensor network app development
- Offers different degrees of “reality”, from simulation to deployment
  - Same code in all realities

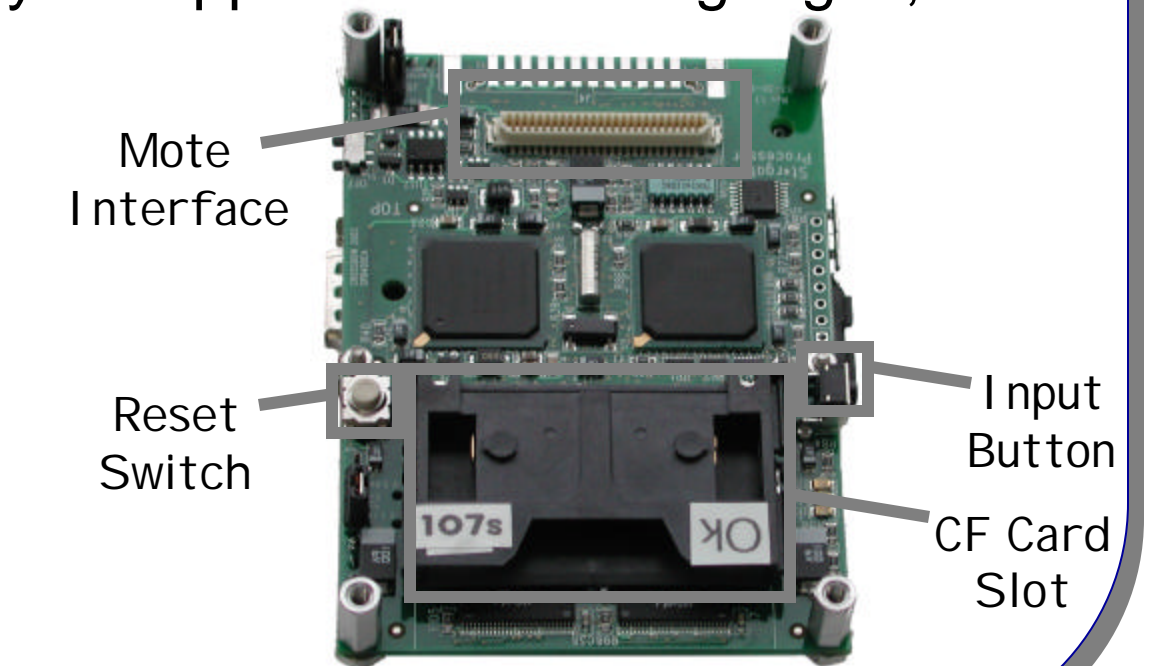


## Stargate Micro-Server

- The Stargate platform developed at Intel Research
- 400MHz Intel XScale® Processor (PXA255)
- 64 MB SDRAM, 32 MB FLASH
- Full Linux software environment
- Easily integrate TinyOS Apps with other languages, libraries, and tools

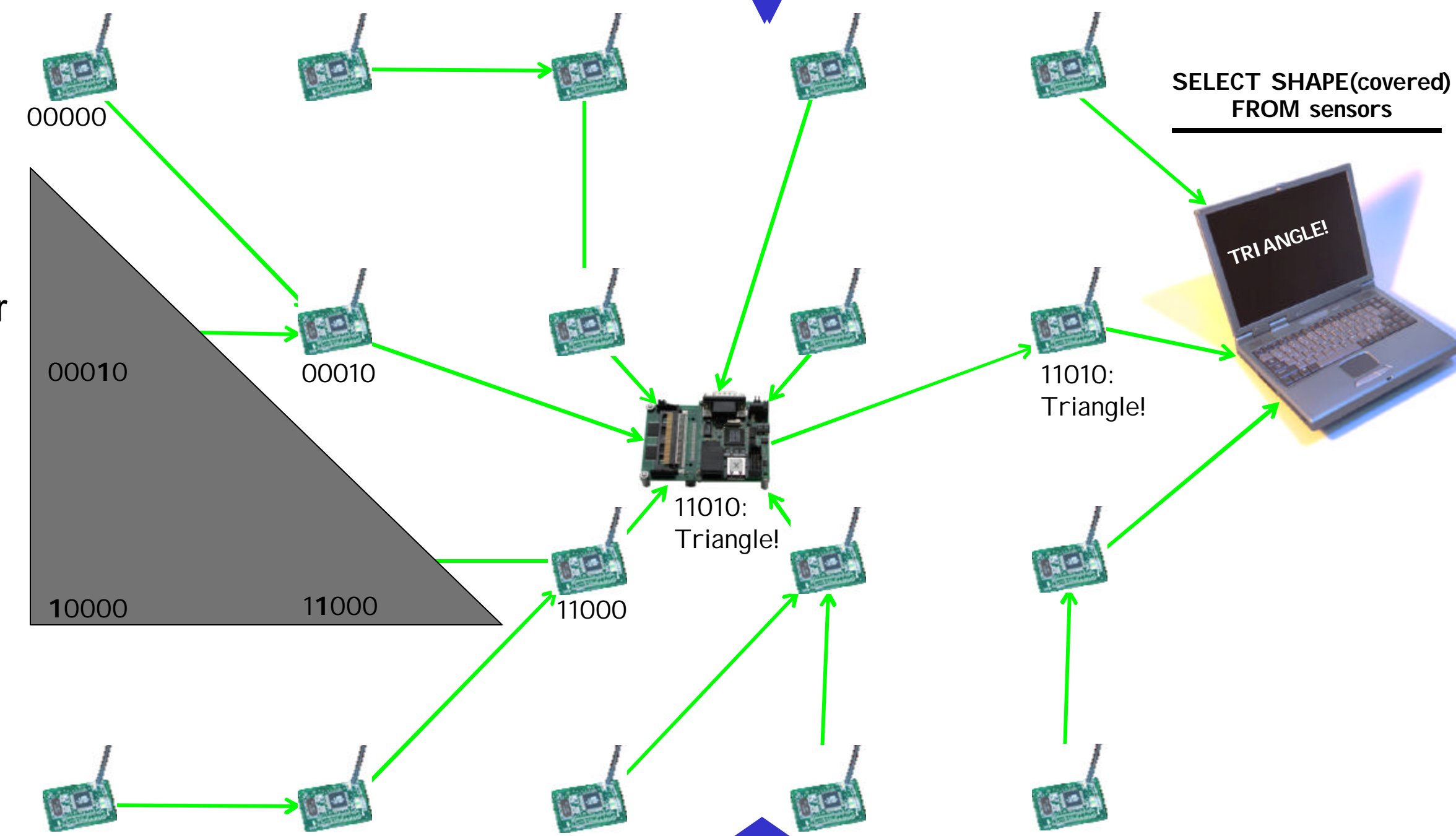


- Integrates into sensor networks through mote interface
- Expandability through PCMCIA, Serial, USB, and CF Card slots
  - Sensors (web cams, GPS)
  - Communication (802.11, Ethernet)
  - Storage (Flash memory)



## In-Network Processing on Heterogeneous Hardware

- Targeting class of applications which require more processing or storage capability
  - These application typically observe the environment for signatures and require FFT's or database lookups
  - Shape detection is representative of storage heavy applications: database of sensor values → shapes
1. TinyDB – Queries network for desired signature
  2. Heterogeneous Routing – Attracts data to Stargate
  3. Stargate – Provides processing and storage for query
  4. EmStar & EmTOS – Runs same code as motes and provides calls to the Linux Environment

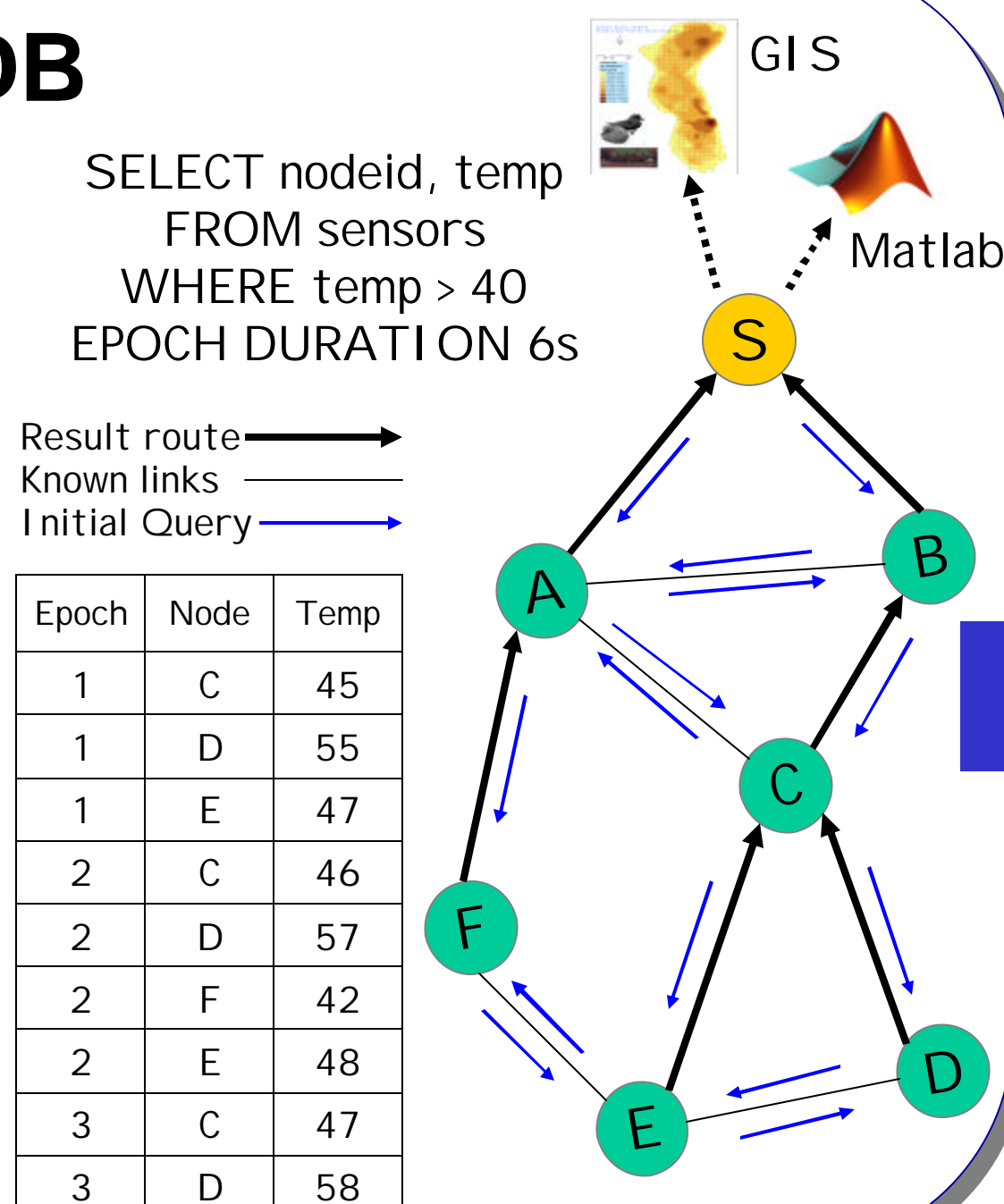


## Shape Detection

- Grid of Mica2 motes detects shape of object placed on top
- Additions to TinyDB
  - *covered* attribute uses light sensor to determine if mote is covered
  - *SHAPE* aggregate merges sensor vales on a mote
  - *SHAPE* aggregate calls EmStar shape component on a Stargate
- Heterogeneous Routing is used to designate the Stargate as a more powerful node
- EmStar shape component looks up sensor values in database and returns list of likely matches
- Shape result merged to aggregate data and forwarded

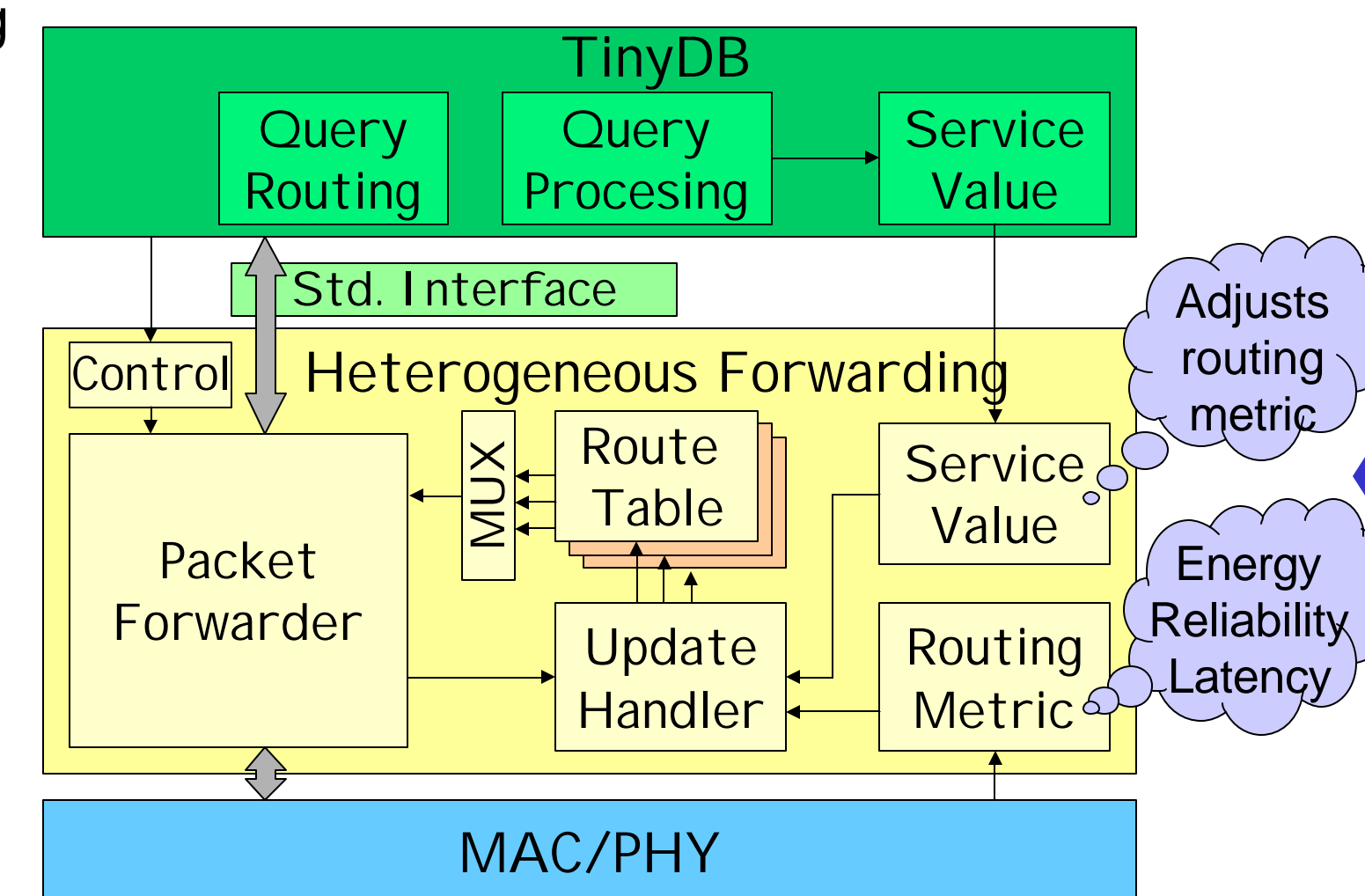
## TinyDB

- Database abstraction for sensor networks
- Query network with SQL variant
  - Queries are temporal
- User develops applications as queries instead of NesC and TinyOS code
- TinyDB provides the data management functions
  - Query optimization, power efficient execution
  - Improve efficiency through the use of aggregates: MAX, SUM, AVG, ...
  - Tree based routing for query delivery, data, collection, and in-network aggregation



## TinyDB + Heterogeneous Routing

- Enable query processing on a subset of nodes
- Attract packets to query processing nodes
- TinyDB specifies the “value” of query processing to the network layer
- Value depends on data reduction “effectiveness” of query



## Heterogeneous Routing

- Packet routing should reflect network resources
  - E.g. Packet aggregation, filtering
- Transparently adjust routes to attract data to resource-rich nodes
- Balance the value of in-network processing against the cost of packet forwarding
- Proactive attraction and aggregation of data reduces overall forwarding cost
- Implemented on top of DSDV

