



# Net-Centric System Modeling Using AADL

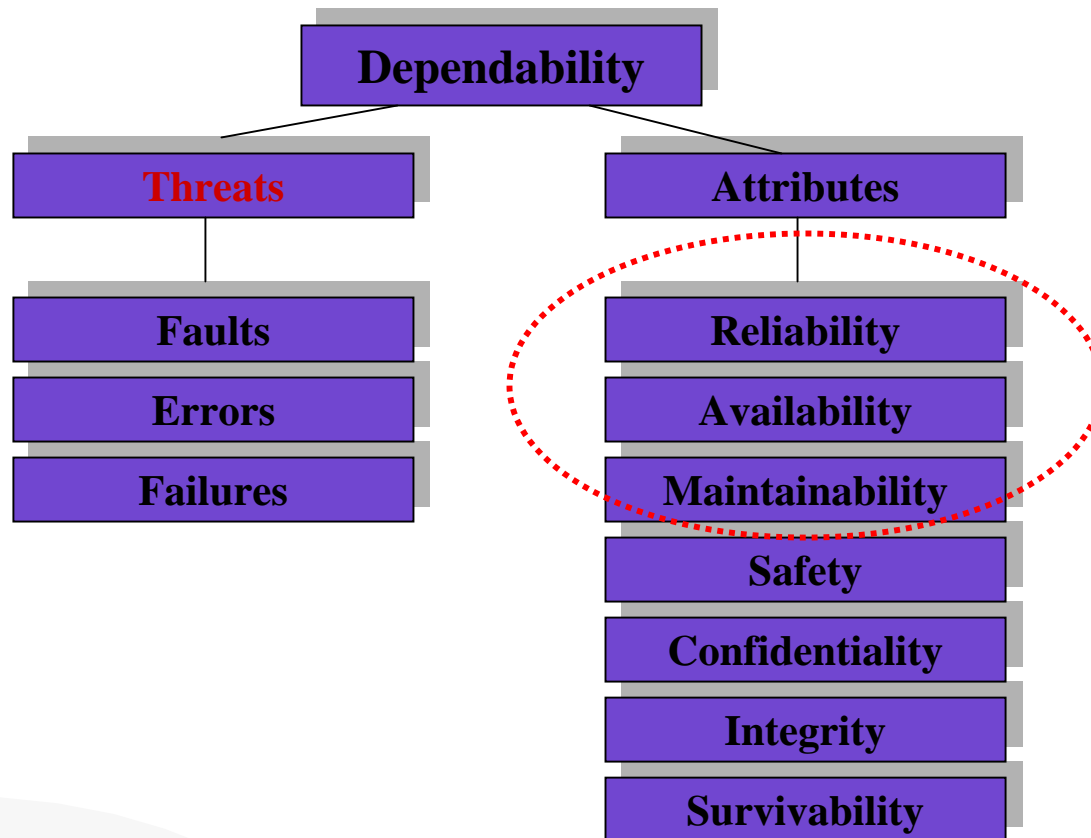
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Innovation Center, Eaton Corporation

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# Dependability

**Dependability** = Ability to deliver a trusted service



# Dependability metrics for WSN

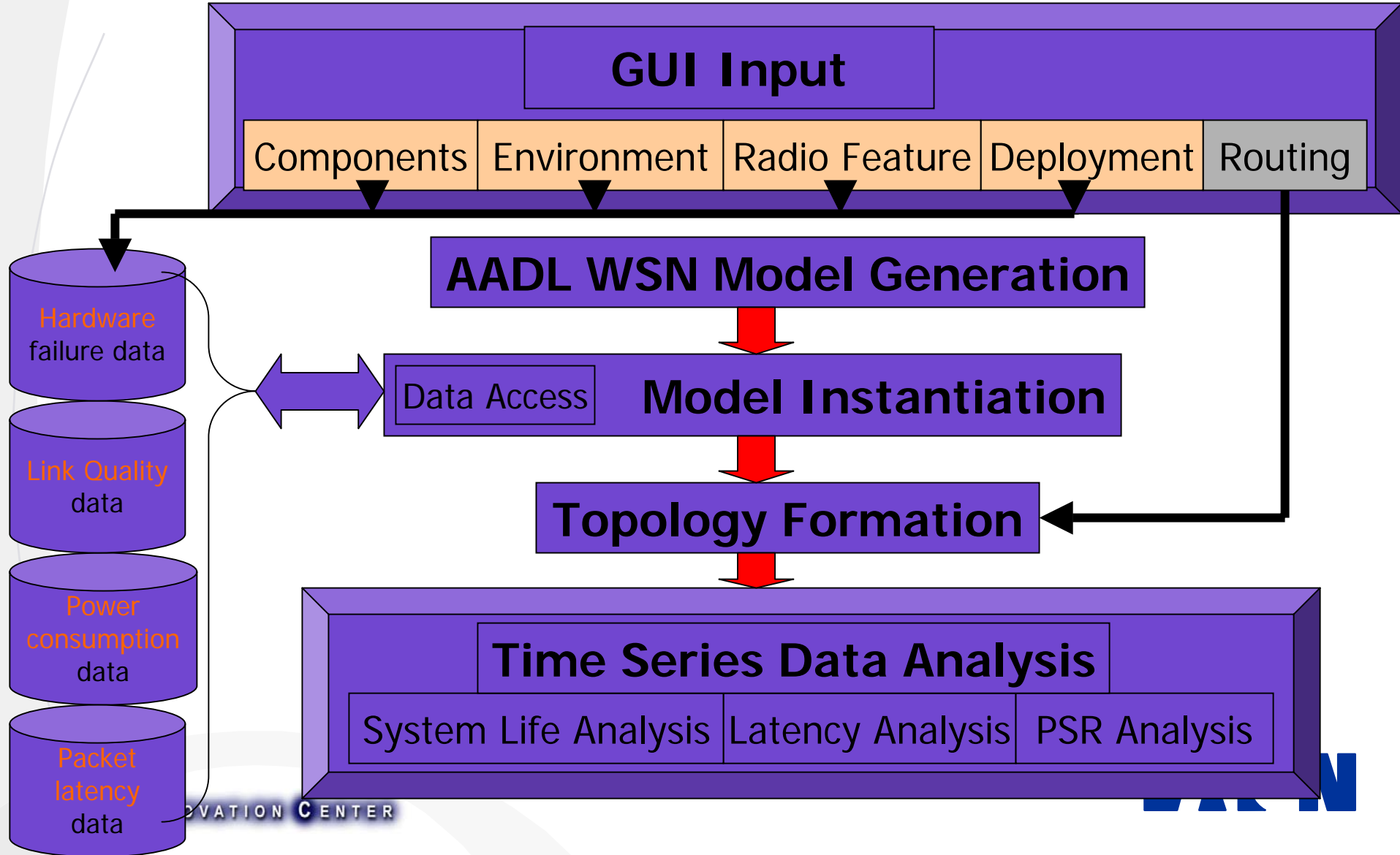
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- *Average Packet Success Rate* → • *Reliability*
- *Average Latency* → • *Availability*
- *Average System Life* → • *Availability,*  
• *Maintainability*

**Note:**

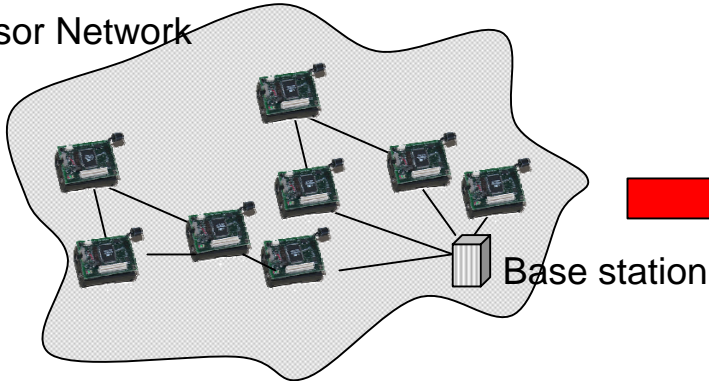
Those values are averaged across all the nodes and over a period of time

# AADL Dependability Analysis Tool Design



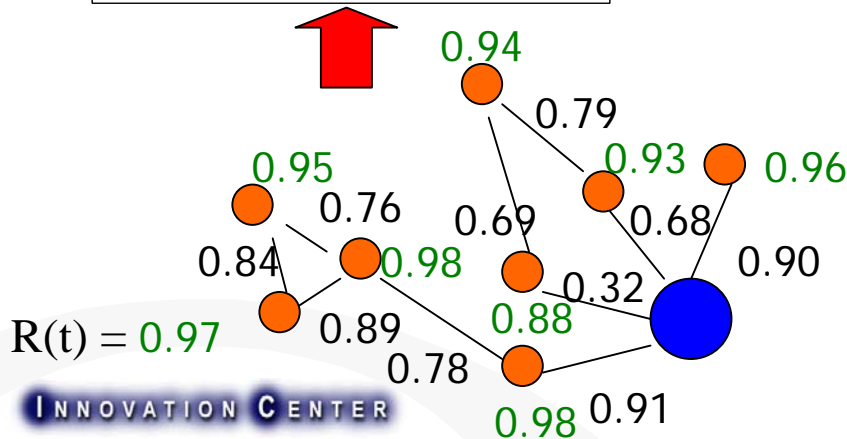
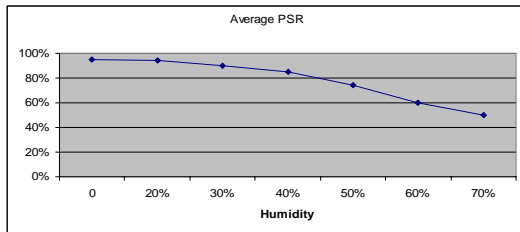
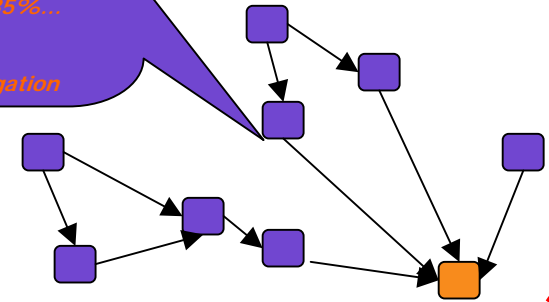
# System to model and analyze

Sensor Network



- Chip: ATmega128L
- Radio: CC2420
- Battery: 2AA-1800MAH
- # of nodes: 8
- Location of nodes: node1(0, 10), node2(10, 15).....
- Environment: humidity 85%...
- MAC: 802.15.4
- Routing: AODV
- Application: data aggregation

AADL Model



Hardware Data

Communication  
Link Data

# Modeling a Sensornet

## AADL Constructs:

### • Software category

- Process
- Subprogram
- Data
- Thread
- Thread group



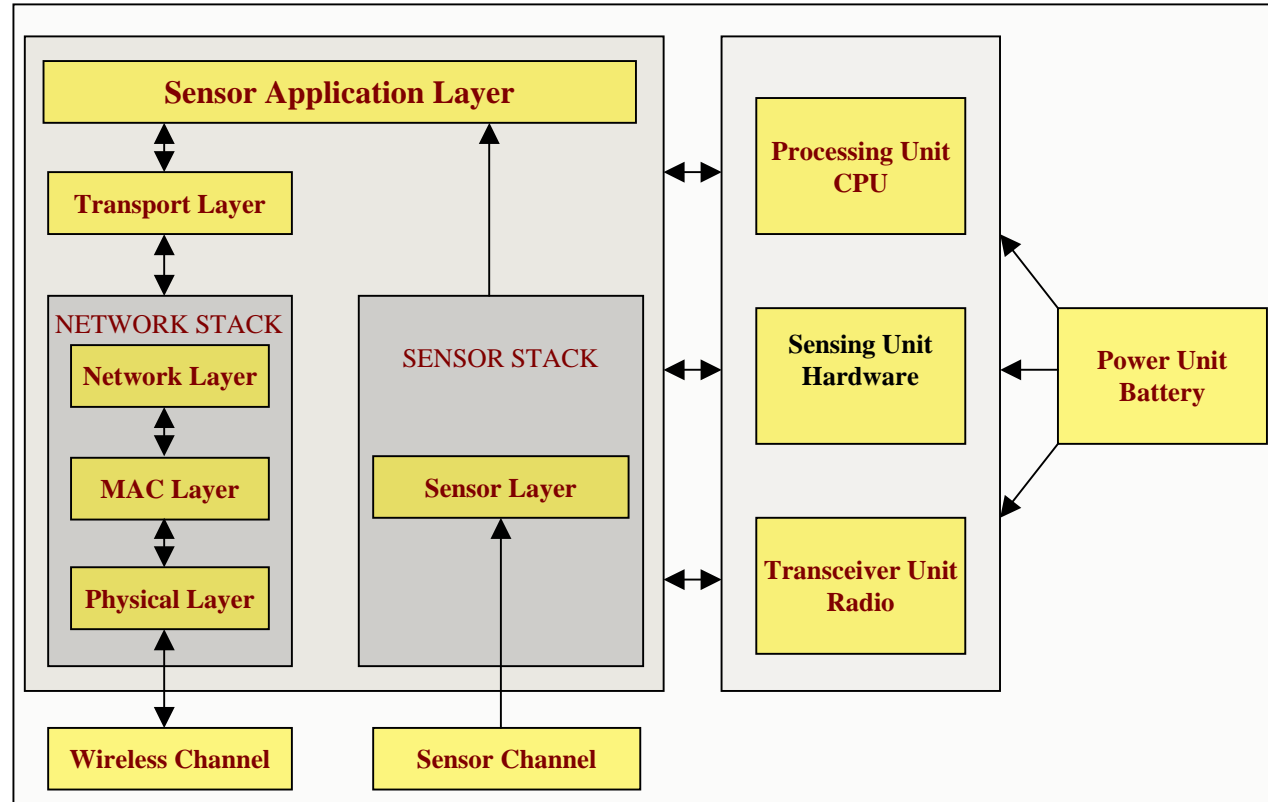
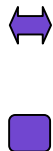
### • Platform category

- Processor
- Memory
- Device
- Bus



### • Composite

- System



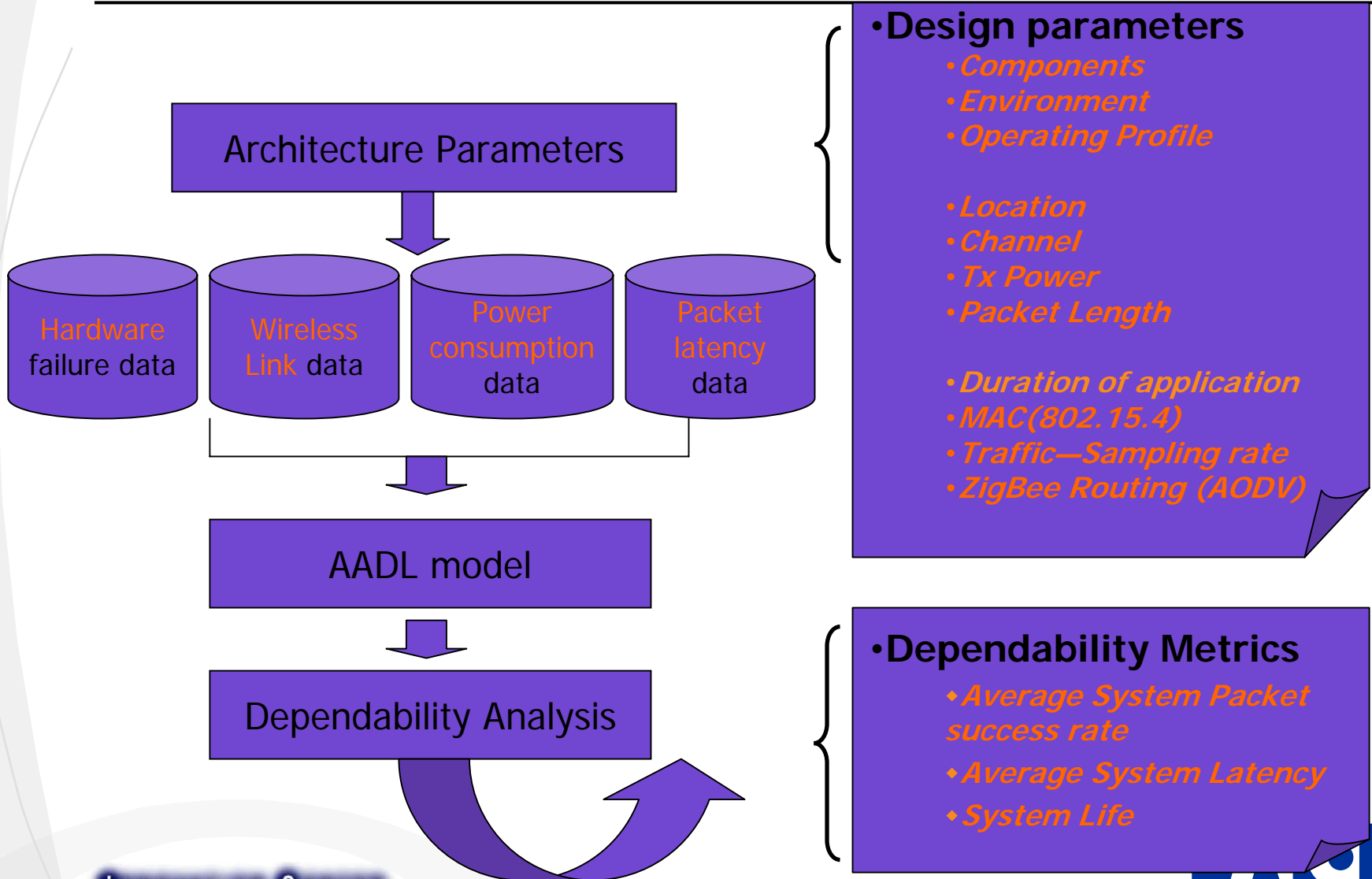
## Mapping

- Layers: **Threads**
- Wireless Channel: **Bus**
- Sensor Channel: **Bus**
- Processing Unit: **Processor**
- Sensing Unit: **Device**

- Transceiver Unit: **Device**
- Power Unit: **Device**
- Sensor Measurements: **Data**
- Messages Exchanged: **Data, Event Ports**



# Data driven Dependability Analysis



# Issues for WSN Modeling

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- What features are not there for effectively modeling wireless sensor networks in the current version of AADL?
  - Effective and flexible means
    - to represent large scale WSN topologies
    - to import empirical/experimental data into the system model
    - to represent time-variant properties
    - to represent node-level state machines

# WSN Topology Specification

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- It is painful to specify each individual node location and link manually for a large scale WSN
- Various ways to manage the issue
  - Fixed topologies – need means to read topology from files
  - Topologies with patterns – grids, uniformly random, ...
    - Specify with patterns and parameters, such as Grid with grid size 10 meters, and have the plug-ins automatically generate the topologies

# Specification of Links

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- Number of links exceeds that of nodes, therefore it is not realistic to have them entered manually for a system with > 100 nodes
- Automatically generate links based on simple models with plug-ins
  - Given the node topologies, base the on/off of links on a circular model with random fluctuations
- Gather link information with experiments, and then import the experimental data into the system

# Specify Time-Variant Properties

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- Some properties are time-variant, e.g., RSSI and LQI, which cannot be specified with the syntax/semantics of the current version of AADL
- Specify time-variant properties
  - Model based specification
  - Import empirical data from experiments

# Specify Node-Level State Machines

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- State machines on each WSN node are necessary to describe system behavior, which is missing in the current version of AADL
  - For example, the communication sub-system of a single node may have states such as SENDING, RECEIVING, WAITING\_FOR\_ACK, ...
  - Need notions of state, transition, ...

# Two Patterns

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- Need to import data from separate files
  - Node locations, link qualities, ...
- Need various levels of details – for example:
  - First level – Grid deployment with density of  $1/100\text{m}^2$
  - Second level – Locations (0m, 0m), (10m, 0m), (20m, 0m), (0m, 10m) ...
  - Use plug-ins to automatically generate the second level model from the first level model

# Proposed Publications

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- AADL tutorial for Embedded System Design magazine
- WSN modeling approach using AADL – WSNA
- AADL for ZigBee – ZigBee conference (yet to be worked out)