A Survey of Modeling Techniques for Wireless Sensor Networks

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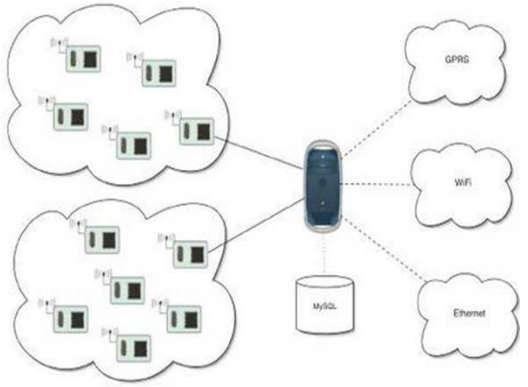
Motivation

Wireless Sensor Network System: *Wireless Sensor Networks (WSNs)* consist of tiny electronic devices called nodes.



Design Challenges:

- Code implementation and debugging is error prone.
- Errors do not appear until they are deployed in the actual devices.
- The distributed nature leads to network delay and power losses
- Limitation of the power resource.

WSN Modeling Techniques

1. HL-SDL
2. Insense
3. Mathworks
4. MEDA
5. PM
6. XRM
7. SystemC-AMS
8. UM-RTCOM
9. SensorML

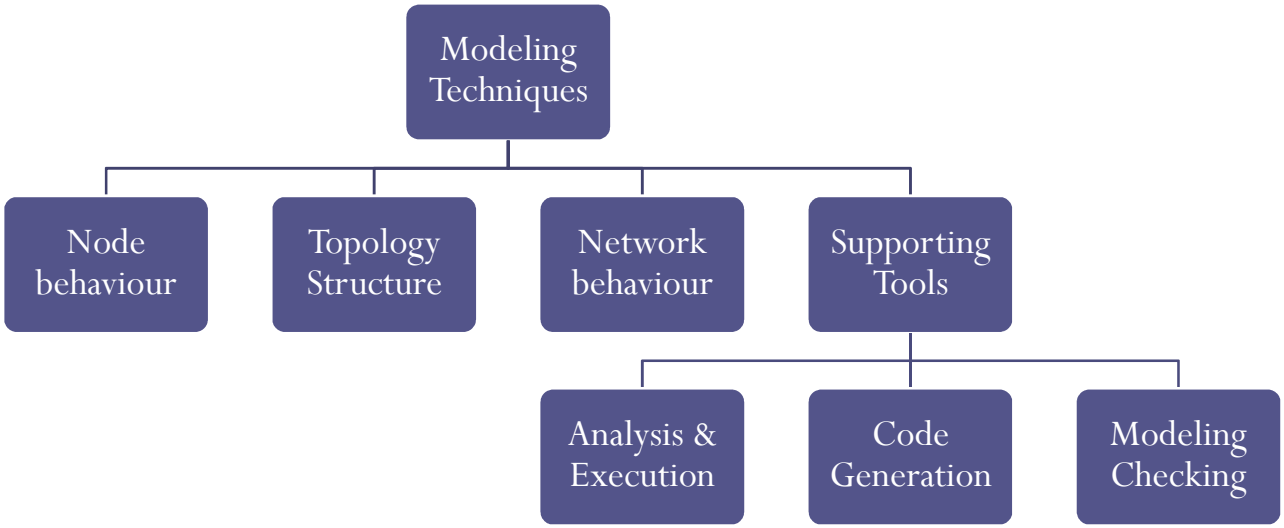
Modeling Notations

- ✓ State Charts
- ✓ Coding methods
- ✓ Activity diagrams
- ✓ Own syntax (such as Insense)
- ✓ UML
- ✓ Block Diagrams
- ✓ C++

The Advantages of Modeling

1. Topology representation.
2. Capture the interaction between the hardware and software components.
3. Capture the performance properties (power resource, time constraints.
4. Performance analysis before the actual the implementation.
5. Generating the implemented code.

Survey classification criteria :



Node Behaviour

- Representation of the node hardware and software elements by using components.

- The interaction between the component is controlled by protocols.
  - ✓ Event Driven
  - ✓ Concurrency
  - ✓ Real –Time Behaviour

- The hardware representation:
  - ✓ Sensor types (Humidity, Temperature,..etc)
  - ✓ Analog to digital converter
  - ✓ Microprocessor
  - ✓ Timer
  - ✓ Ports
  - ✓ Communication channels.

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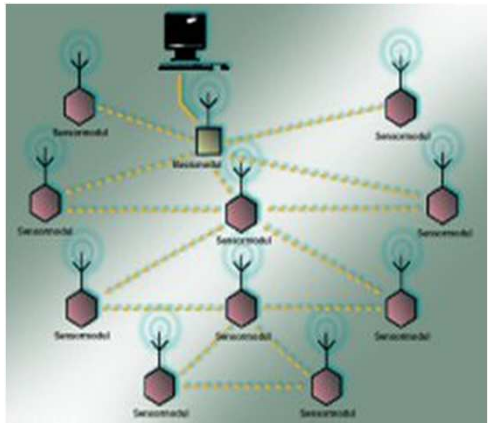
Node Behaviour

Approach	Node Behaviour	Sensor & Hardware Modeling
HL-SDL	Concurrency, event driven	-
Insense	Concurrency, real-time	Sensor Types
Mathworks	procedural, state space	-
MDEA	procedural, state space	timers, ports, wireless channel
PM	-	-
SensorML	Event driven	Sensor types
SystemC-AMS	procedural	ADC, microprocessor, wireless channel
UM-RTCOM	concurrency, real-time, event-driven	-
XRM	procedural, state space	-

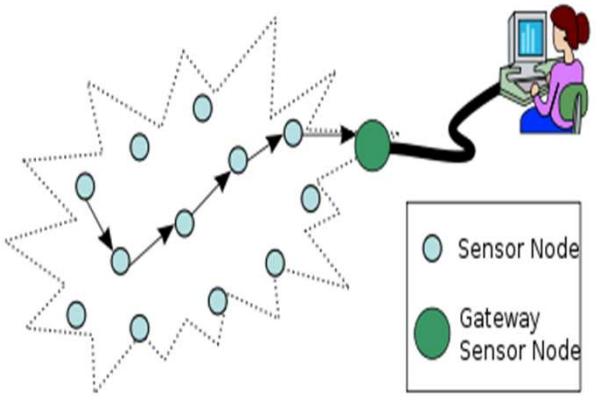
Network Behaviour

- Representation of the network elements which are nodes, actor, base station.
- Capturing the nodes activity, nodes interaction, nodes –base station interaction.
- Network life time.
- Grouping of the modelled elements.



Topology Structure

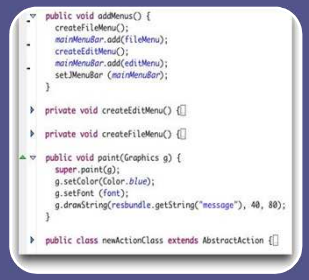
1. Single hop of communication
2. Multi- hop of communication
3. Dynamic Topology (moving sensors).
4. Static Topology.



Topology Structure &Network Behaviour

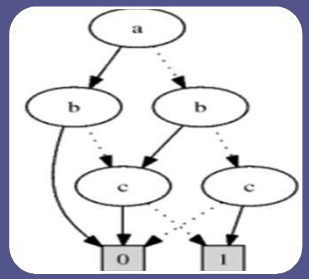
Approach	Network Behaviour	Topology Modeling
HL-SDL	-	-
Insense	-	-
Mathworks	Node/base station interaction	Single hop, static topology
MDEA	Node/base station interaction	-
PM	Nodes connectivity	Multi hop, dynamic topology
SensorML	-	-
SystemC-AMS	-	Single hop, static topology
UM-RTCOM	Nodes/actors/base station interaction	Single hop, static topology
XRM	Power management wake up states	Single hop, static topology

Supporting Tools



Code Generation

- Save a lot of effort of implementing the actual code
- One –to one transformation rules.
- Draw backs.



Model Checking

- Specify the design structure and the system specification.
- For WSN, check the system correctness or supply the error counter
- For WSN, direct and indirect model checking.

Analysis

- Calculating the system performance parameters such SNR, BER.
- Real-time analysis such WECT and deadlock of the network.

Supporting Tools

Approach	Code Generation	Model Checking	Analysis & Execution
HL-SDL	NesC	-	WECT
Insense	C	Spin (Channel Protocol)	WCS
Mathworks	NesC, C	-	Functional analysis
MDEA	NesC	-	-
PM	-	Spin (Connectivity)	-
SensorML	JavaBeans	-	-
SystemC-AMS	-	-	BER, SNR
UM-RTCOM	-	-	Deadlock, WECT
XRM	-	Prism, APMC	Execution, debugging

Conclusion

✓The scope of the modeling technique.

- The WSN system.
- The node.

✓The topology representation can be captured by:

- Using grid representation.
- Assumption of single hop or multi-hop.
- Declaration of the variables.

✓Handling the design challenges by the supporting tools.

✓Modeling Techniques Limitations.

- The absents for analysis of overall system delay.
- Battery models.
- Trade-off between delay and power consumption
- Enhancing the design based on analysis results.

Questions