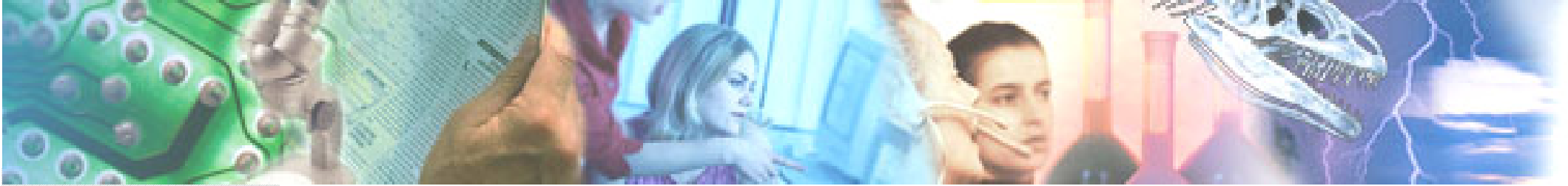




**« Proposition of a Real-Time MAC protocol
for Wireless Sensor Networks »**

Thomas Watteyne
supervisor : Isabelle Augé-Blum
CITI Laboratory

Recap meeting, 13th june 2005



Real-Time

Monitoring applications with alarms

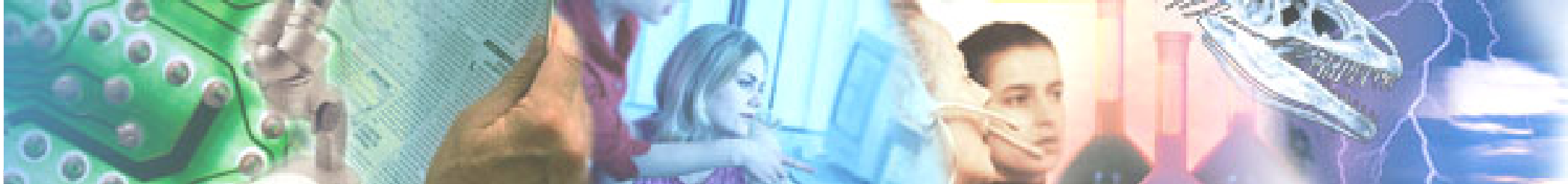


« natural » Real-Time constraints

« Very few results exist to date regarding meeting real-time requirements in WSN [...], no guarantees are given. »

*John A. Stankovic, University of Virginia
Research Challenges for Wireless Sensor Networks,
2004*



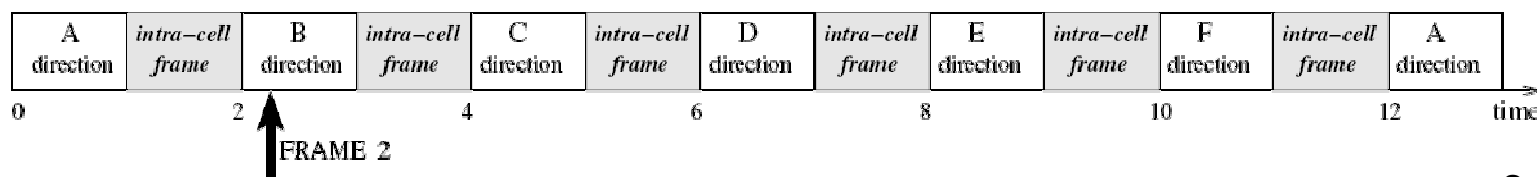
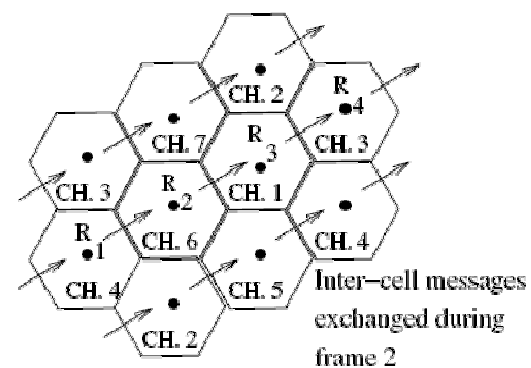
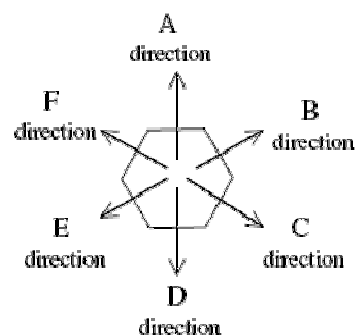


Real-Time

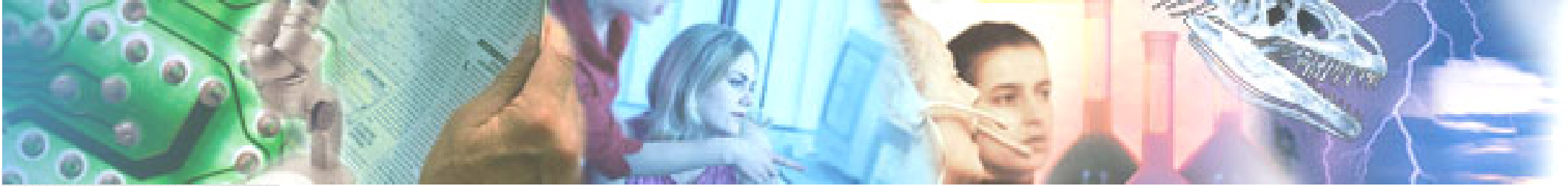
Soft Real-Time proposals

Or

Hard Real-Time with hard-to-meet requirements



Inter-cellular communication in I-EDF

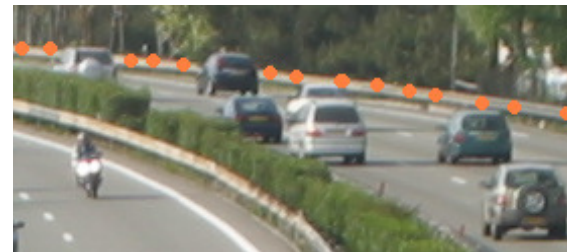
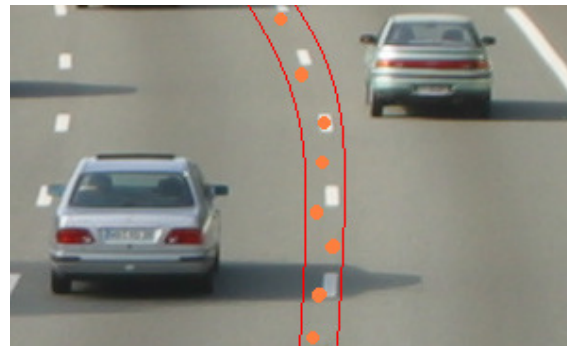


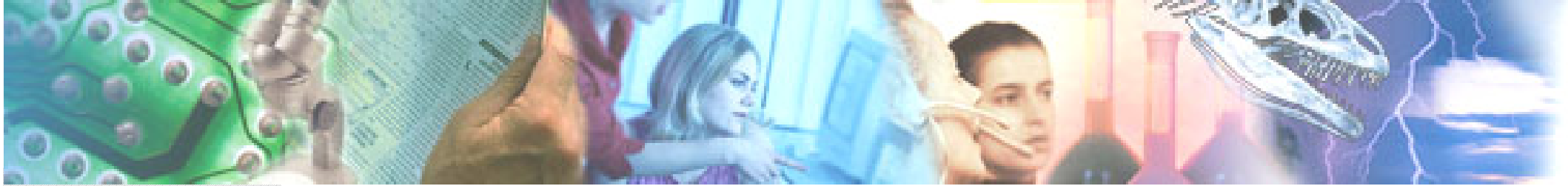
Goal

“Propose a MAC protocol supporting hard real-time constraints for WSN”



Example: highway car accident detection





Hypothesis

Nodes

- no specific nodes
- one frequency, same power
- no GPS (*positioning, synchronization*)
- position aware

Monitored area

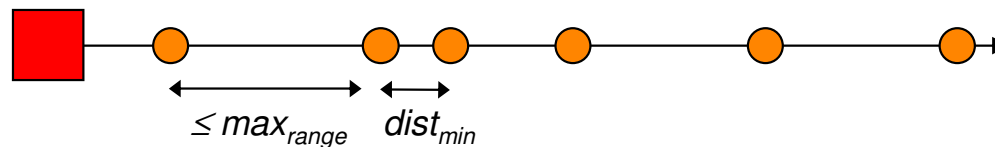
- linear
- $dist_{min}$

Wireless link

- bidirectionnality
- if B between A and C, if A and C communicate, B communicates with A or C
- no transmission errors

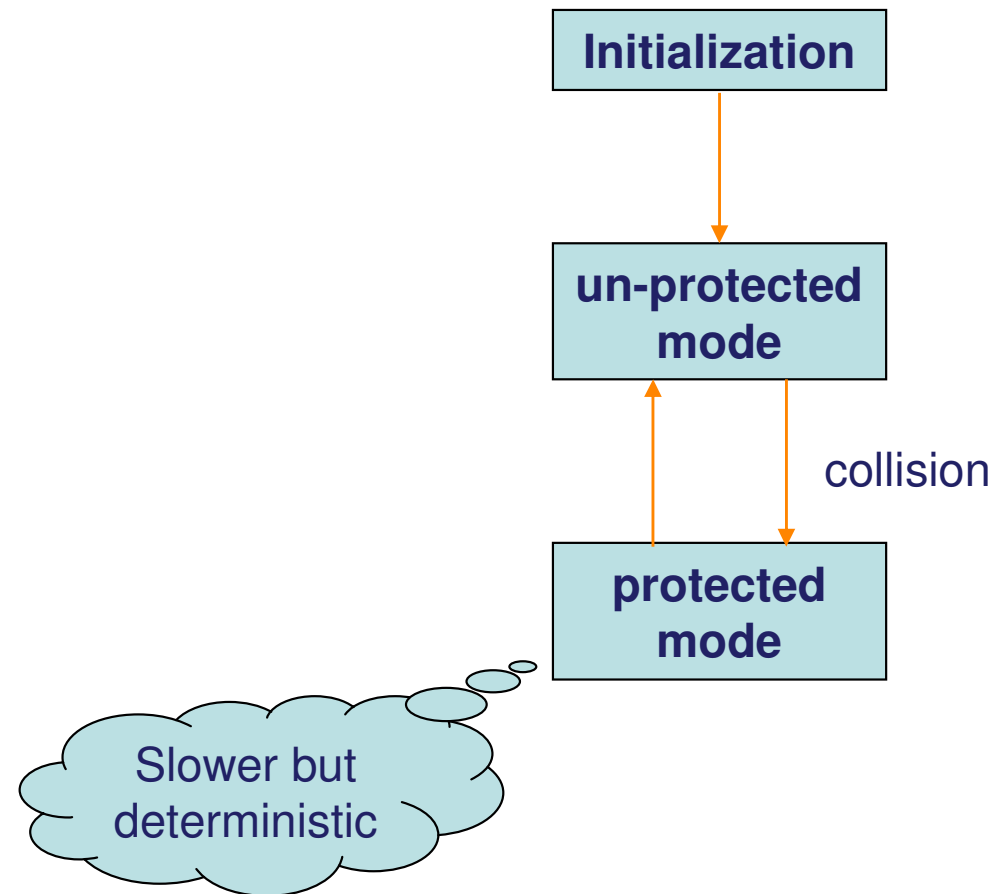
Alarms

- from any node
- no priorities

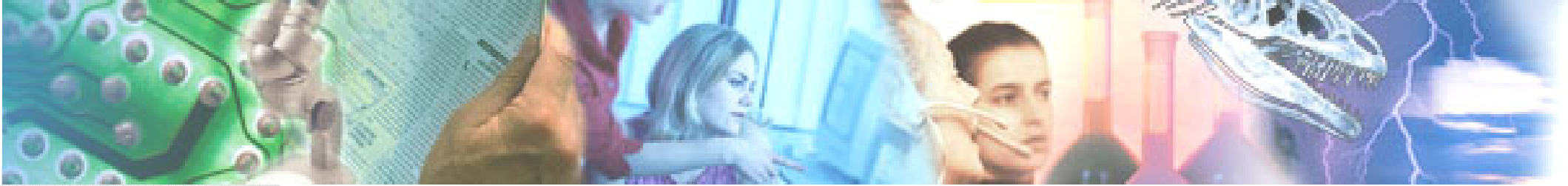




Overview



WCET...



Initialization

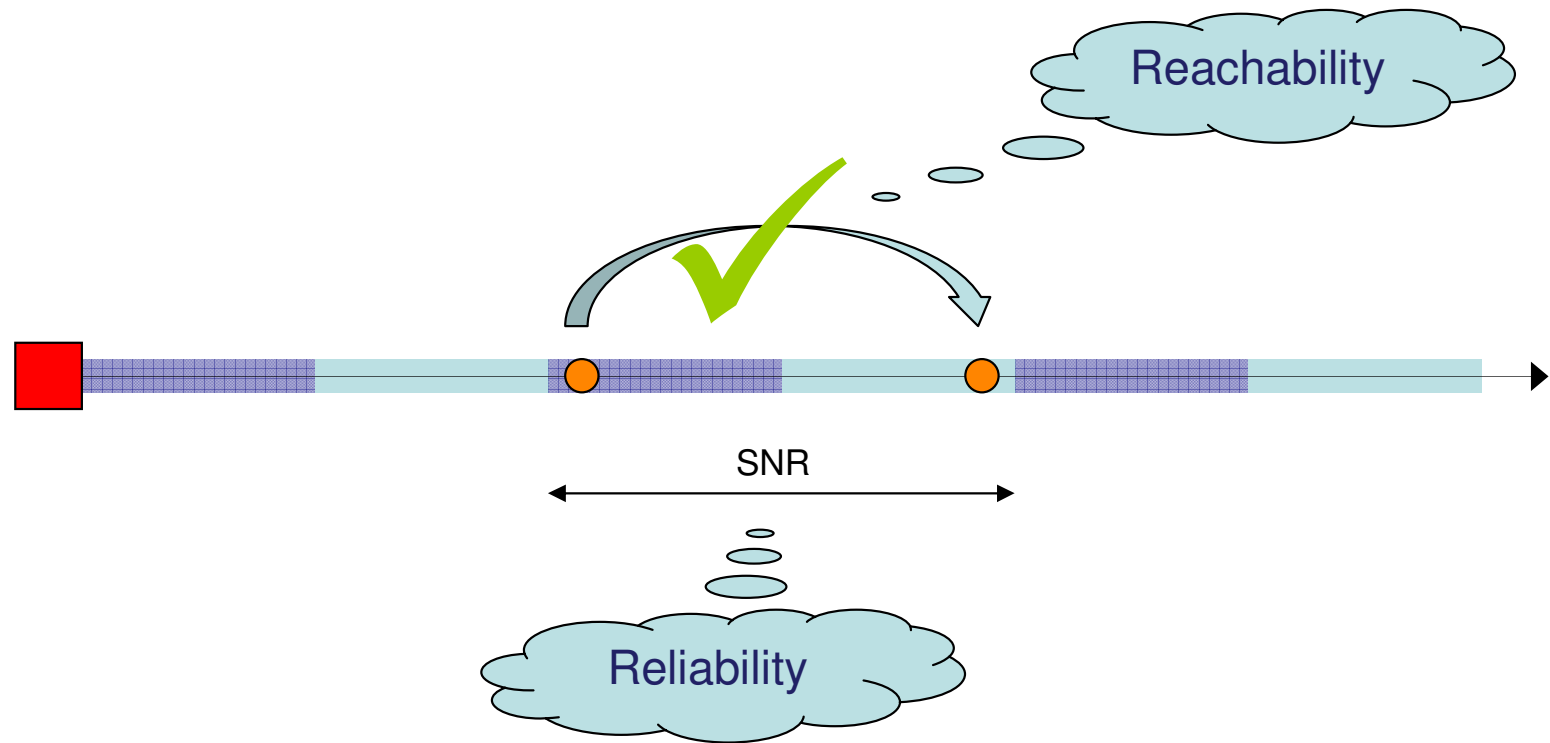
Un-protected

Switch

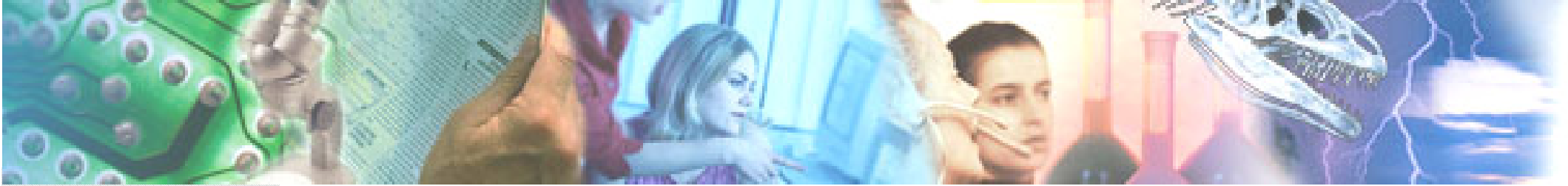
Protected

Switch

Initialization



2 types of messages: *CREATION* & *END_INIT*



Initialization

Un-protected

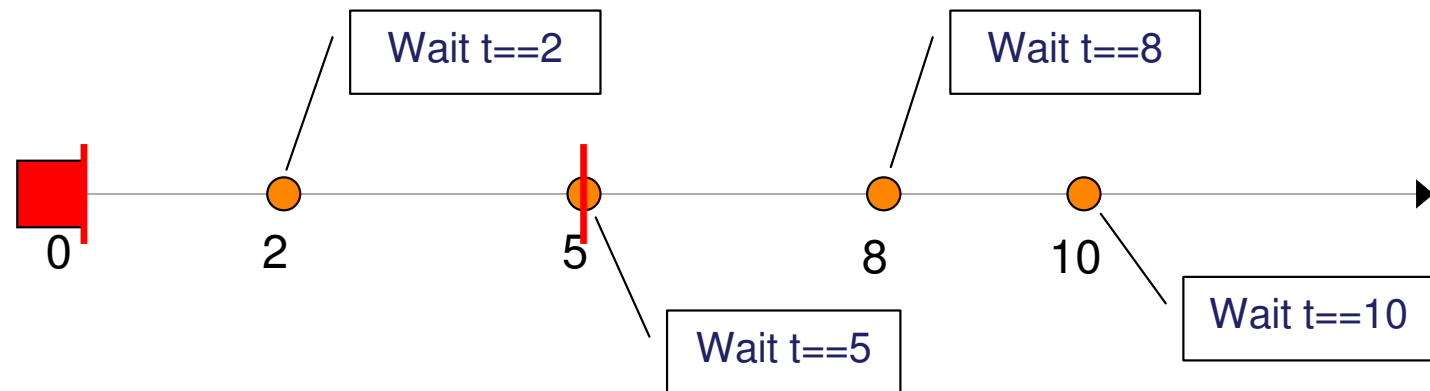
Switch

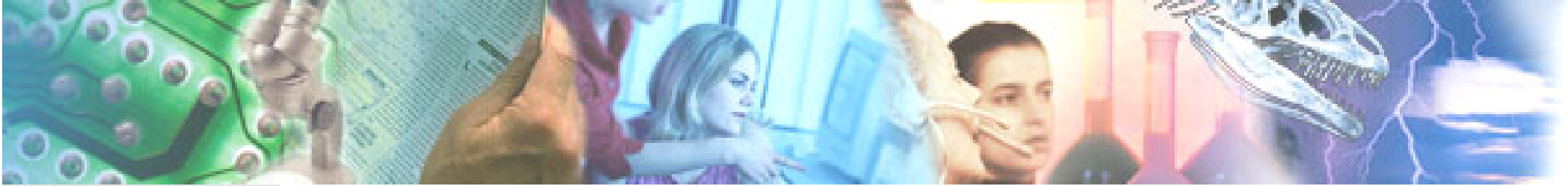
Protected

Switch

Medium Access Control

Backoff Scheme





Initialization

Un-protected

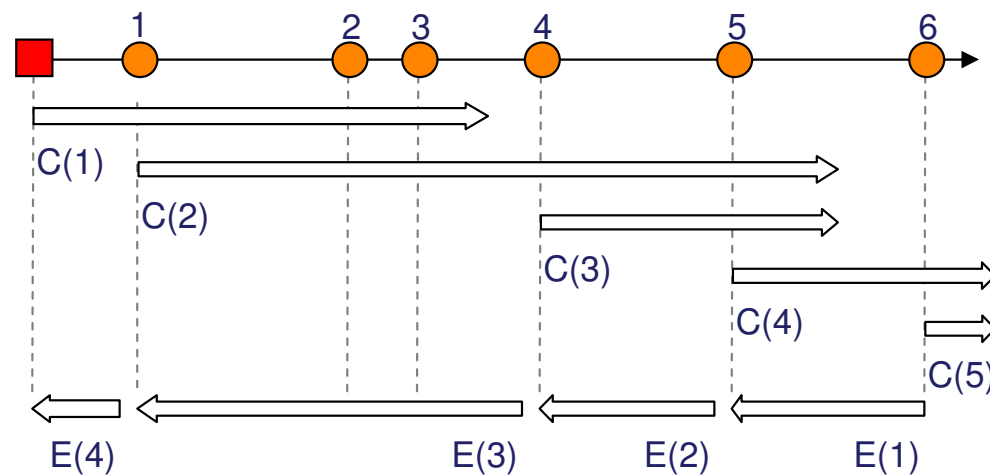
Switch

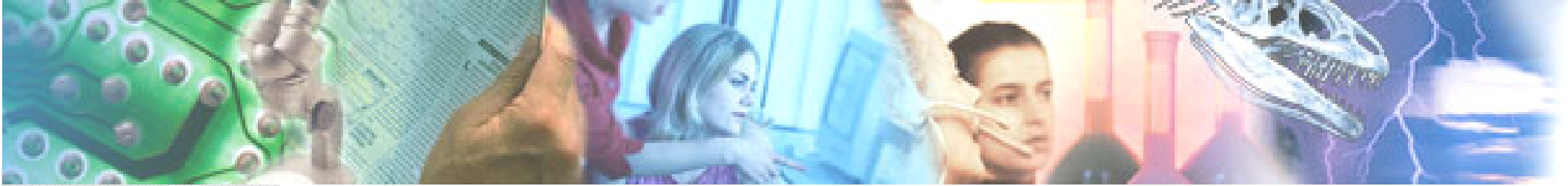
Protected

Switch

Algorithm

received	to be sent	Cell number
$C(i)$	$C(i+1)$	$i+1$
$C(i) \& C(i+1)$	<i>nothing</i>	$i+1$





Initialization

Un-protected

Switch

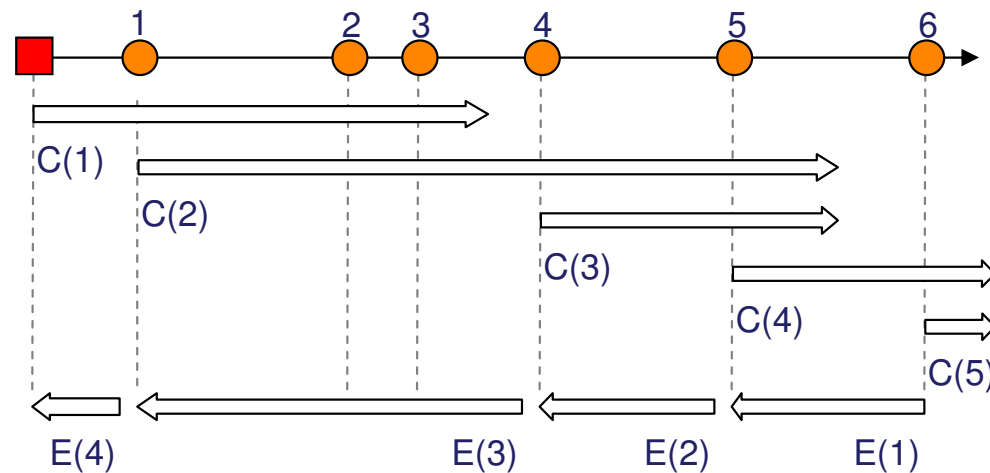
Protected

Switch

Algorithm

$$timer_{last_node} = \frac{2 \times \max_{range}}{W_{initialization}}$$

$$timer_{problem} = \frac{2 \times \max_{range} - (A - A_{CREATION(i+1)})}{W_{initialization}}$$





Initialization

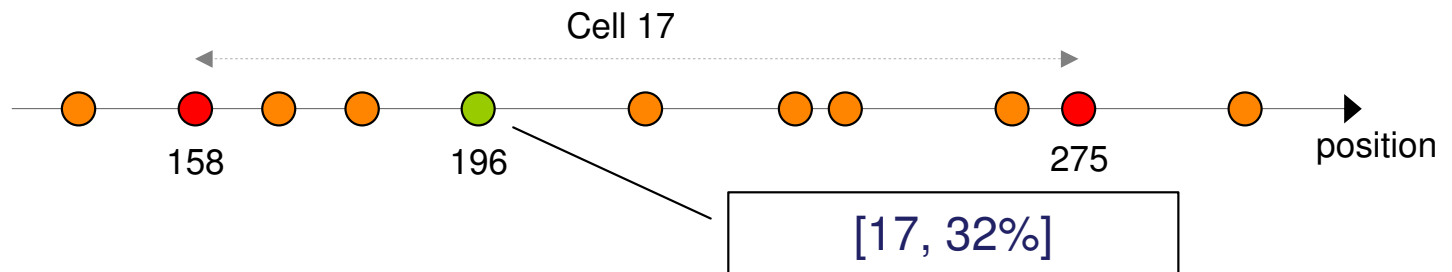
Un-protected

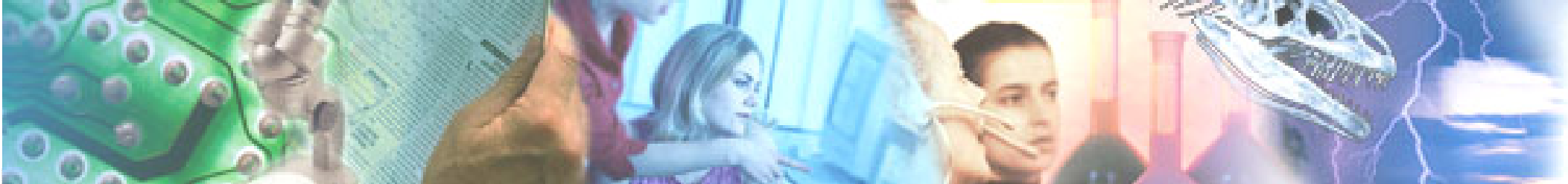
Switch

Protected

Switch

Identification





Initialization

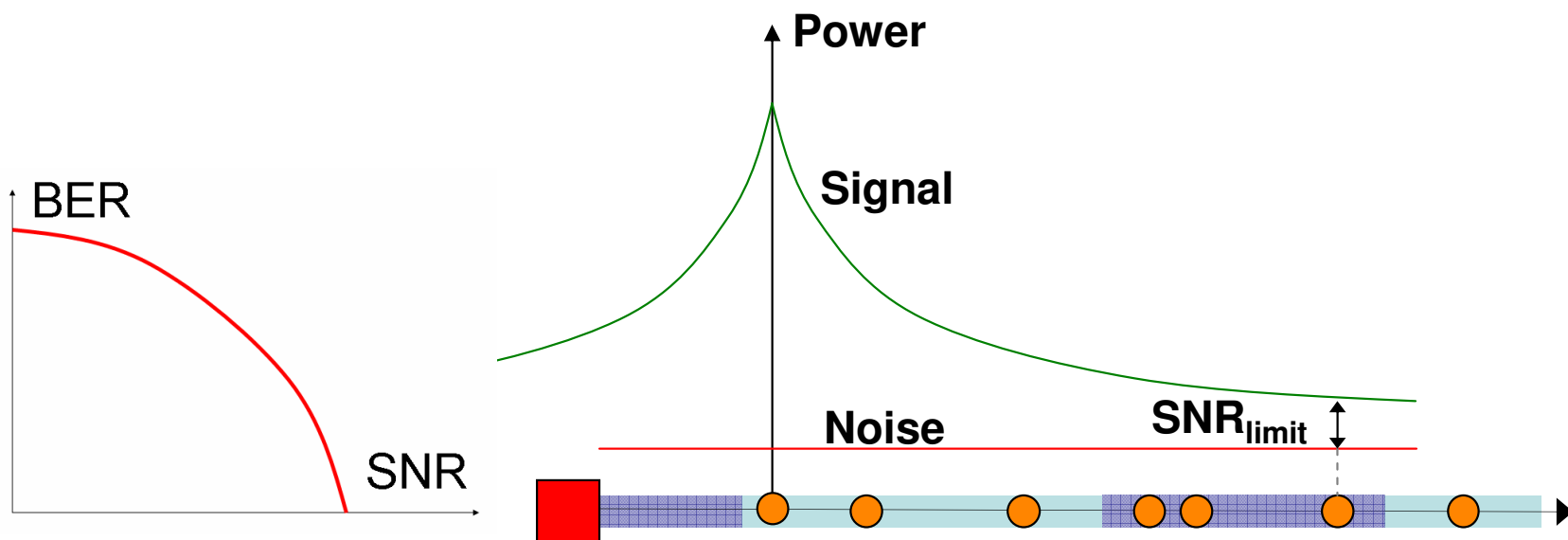
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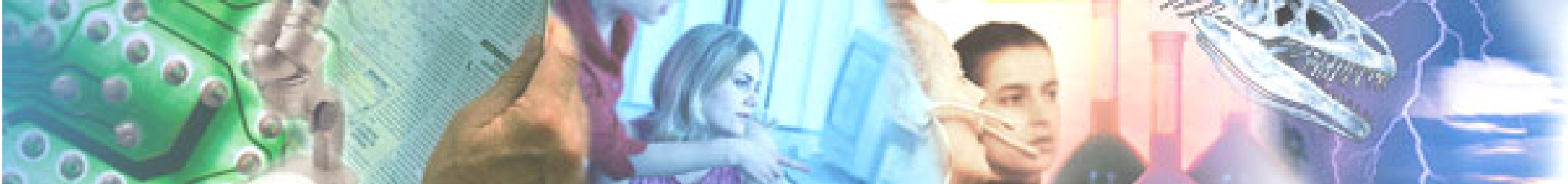
Switch

Protected

Switch

Reliability





Initialization

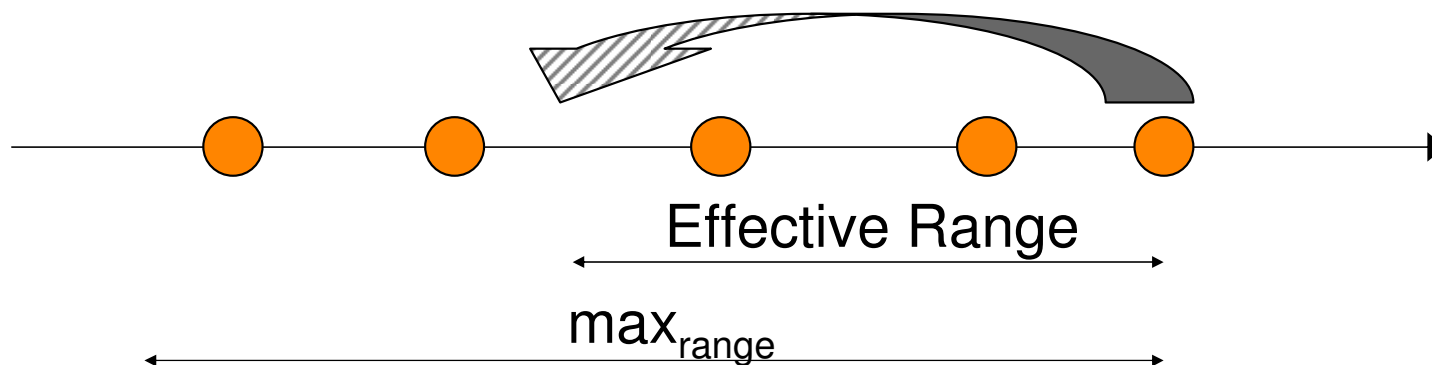
Un-protected

Switch

Protected

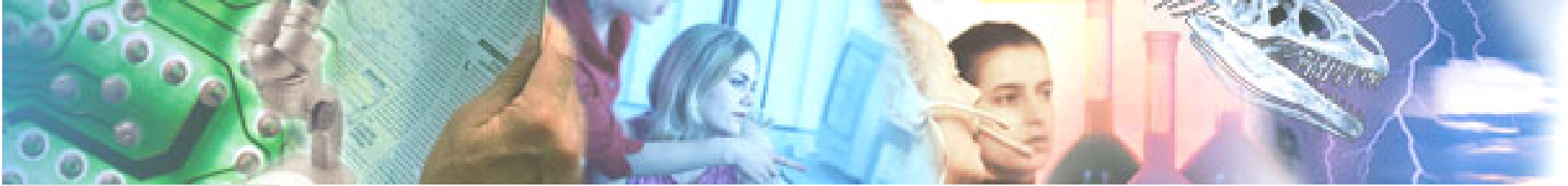
Switch

Un-protected mode



Near Optimal

$$backoff_{unprotected} = \frac{A - (A_{emitting} - \max_{range})}{W_{emission}}$$



Initialization

Un-Protected

Switch

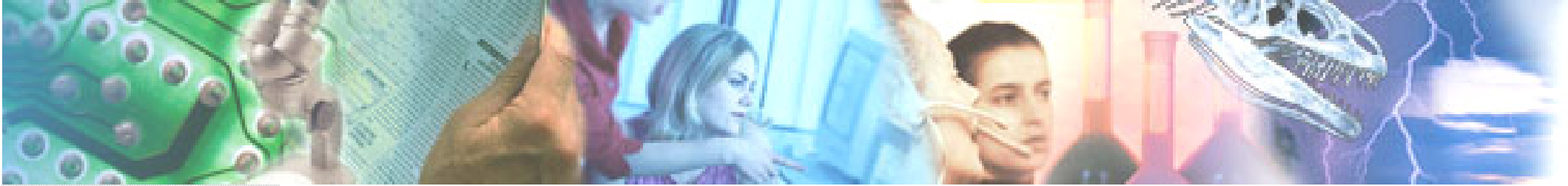
Protected

Switch

Switching to protected mode



- Node receives a JAM message → reemits it once
- After $WCET_{jam}$, protected mode



Initialization

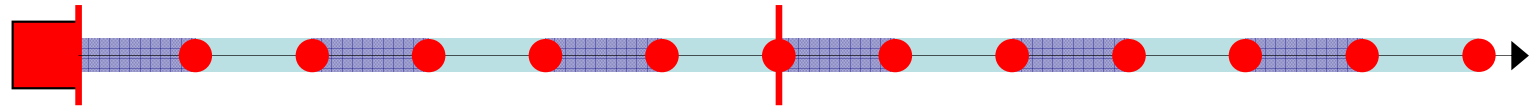
Un-Protected

Switch

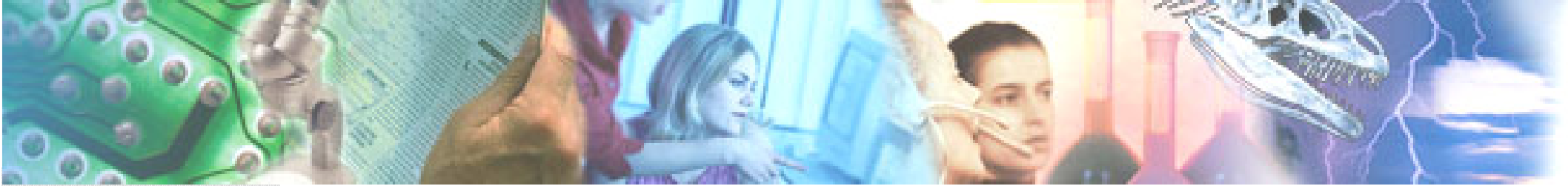
Protected

Switch

Network synchronization



- No GPS \Rightarrow synchronization on a « passing wave »
- $W_{\text{synchronization}}$
- 6 cells for simultaneous emissions not to interfere



Initialization

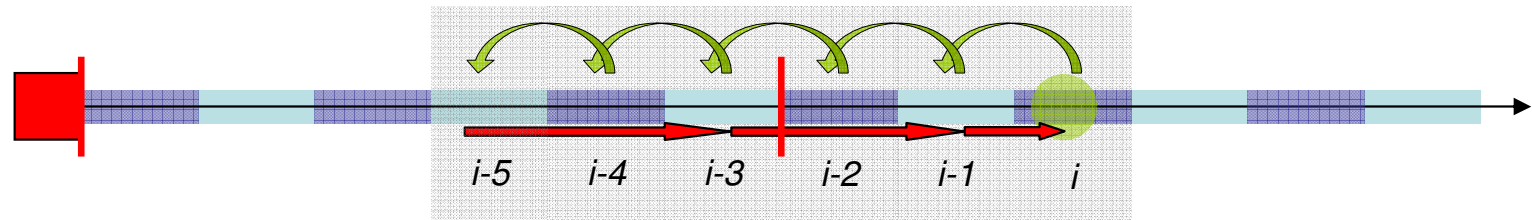
Un-Protected

Switch

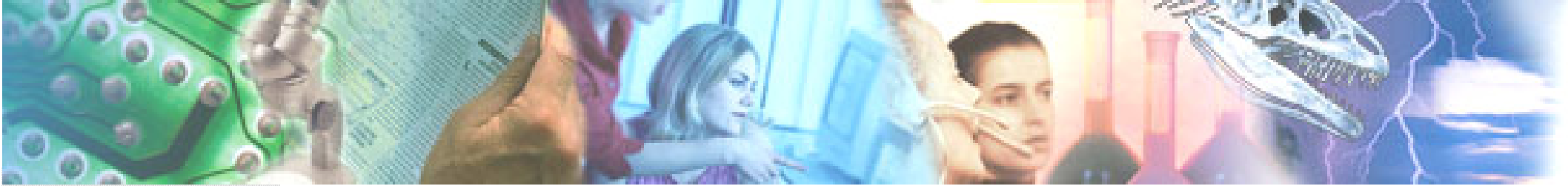
Protected

Switch

Protection



- Node i wants to send an alarm
- If node i is in **idle** mode, it switches to **reservation(0)** mode and sends out a **SILENCE(1)** message to half-cells $i-1$ when the wave hits him.
- $i-1$ enters **reservation(1)** mode and send out a **SILENCE(2)** message to half-cell $i-2$ when de wave hit's it.
- ...
- $i-5$ enters **reservation(5)** mode and sends out an **ACK_EXP** message when the wave hits it, relayed back as fast as possible to cell i .



Initialization

Un-Protected

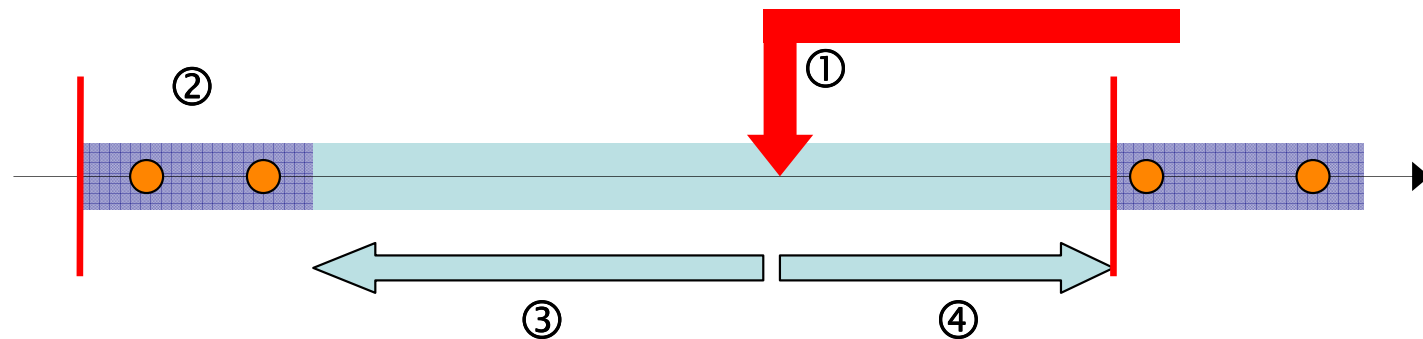
Switch

Protected

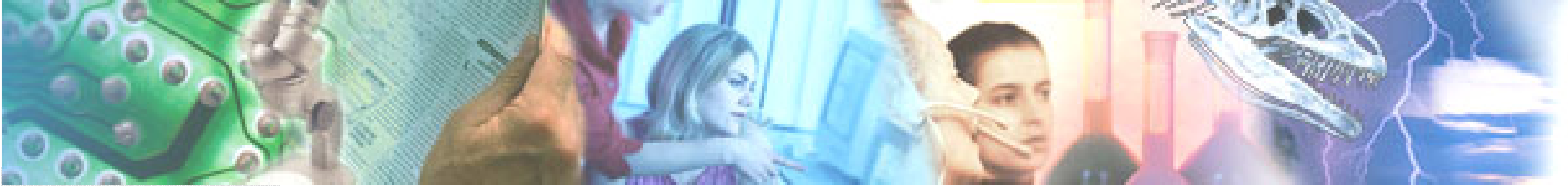
Switch

Protection

Election of re-emitting node



1. Hear signaling message
 2. Wait for a synchronization wave to enter the half-cell, you have $100\% \times V_{\text{synchronization}}$ seconds
 3. Give chance to higher nodes
 4. Give chance to lower nodes
- } Until some node emits



Initialization

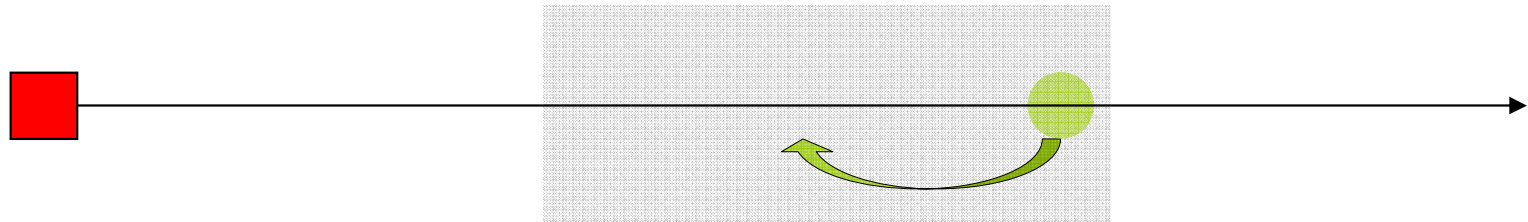
Un-Protected

Switch

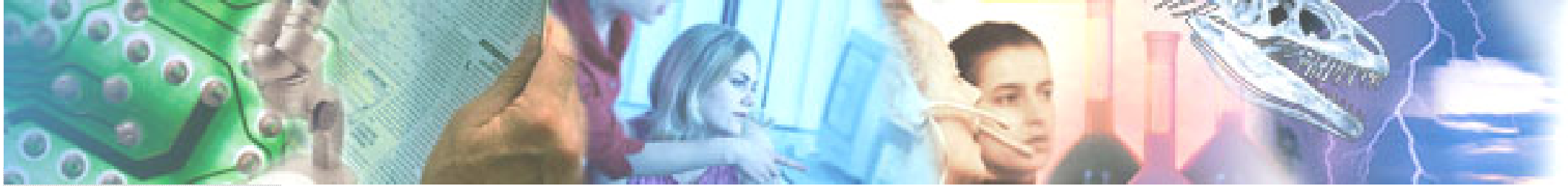
Protected

Switch

Transmission



- Equal to un-protected mode but re-emitting node starts new protection phase



Initialization

Un-Protected

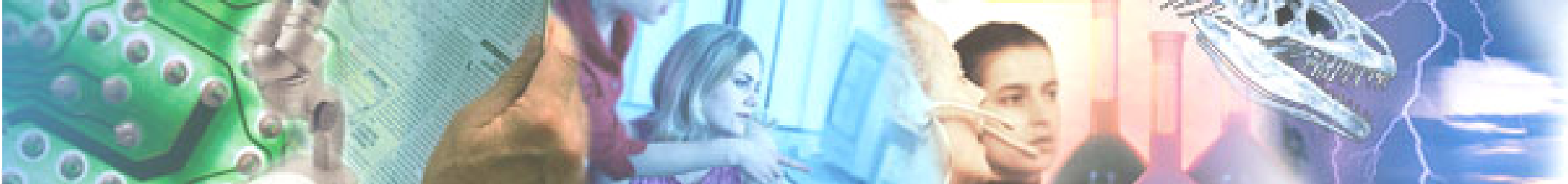
Switch

Protected

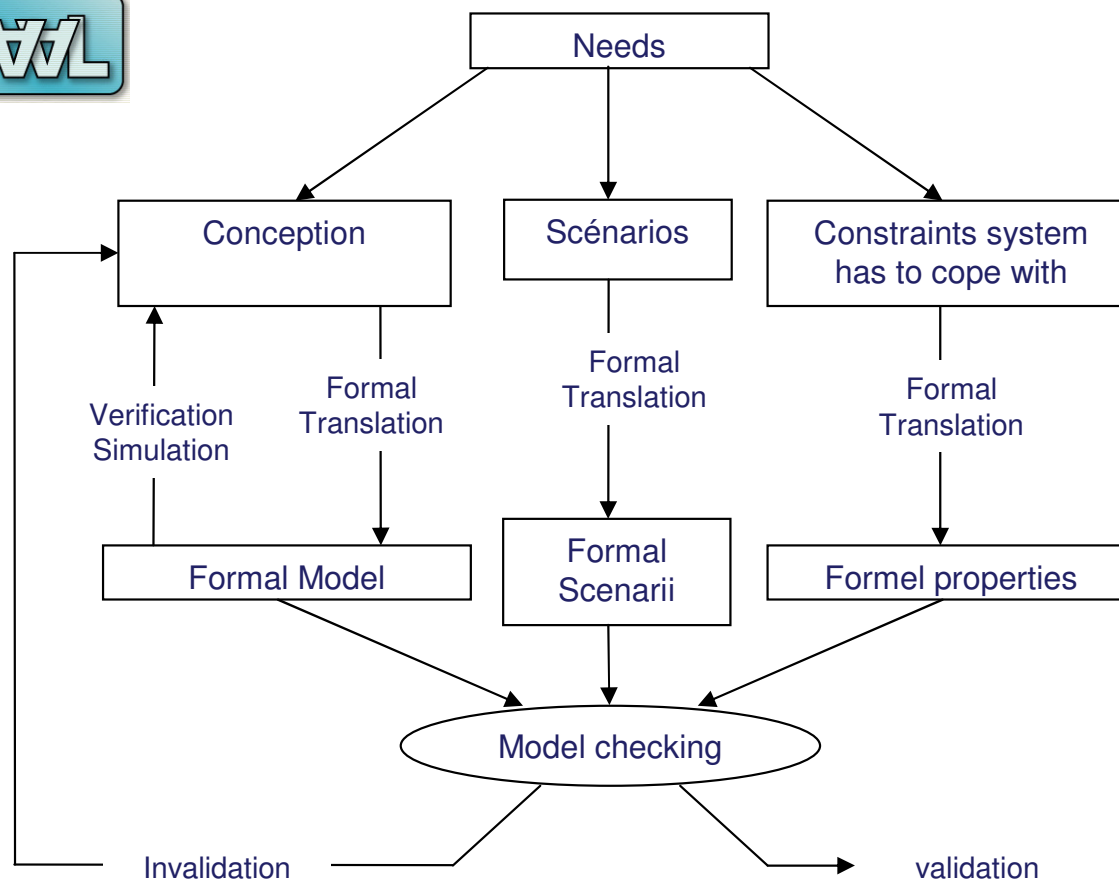
Switch

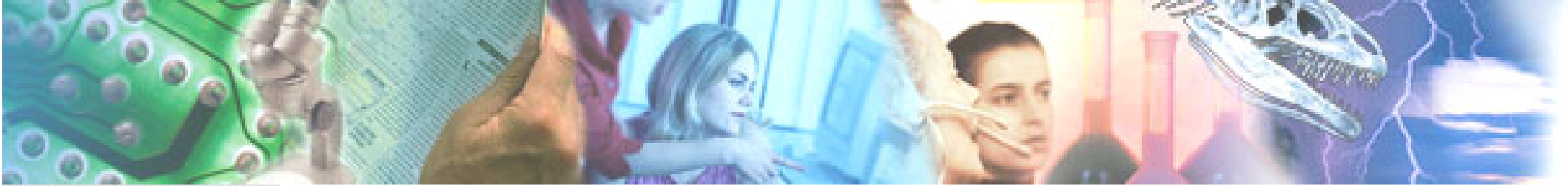
Switching back to un-protected

- Sink waits for an idle period to occur
- sends out JAM signal
- after $WCET_{jam}$, networks starts up in un-protected mode

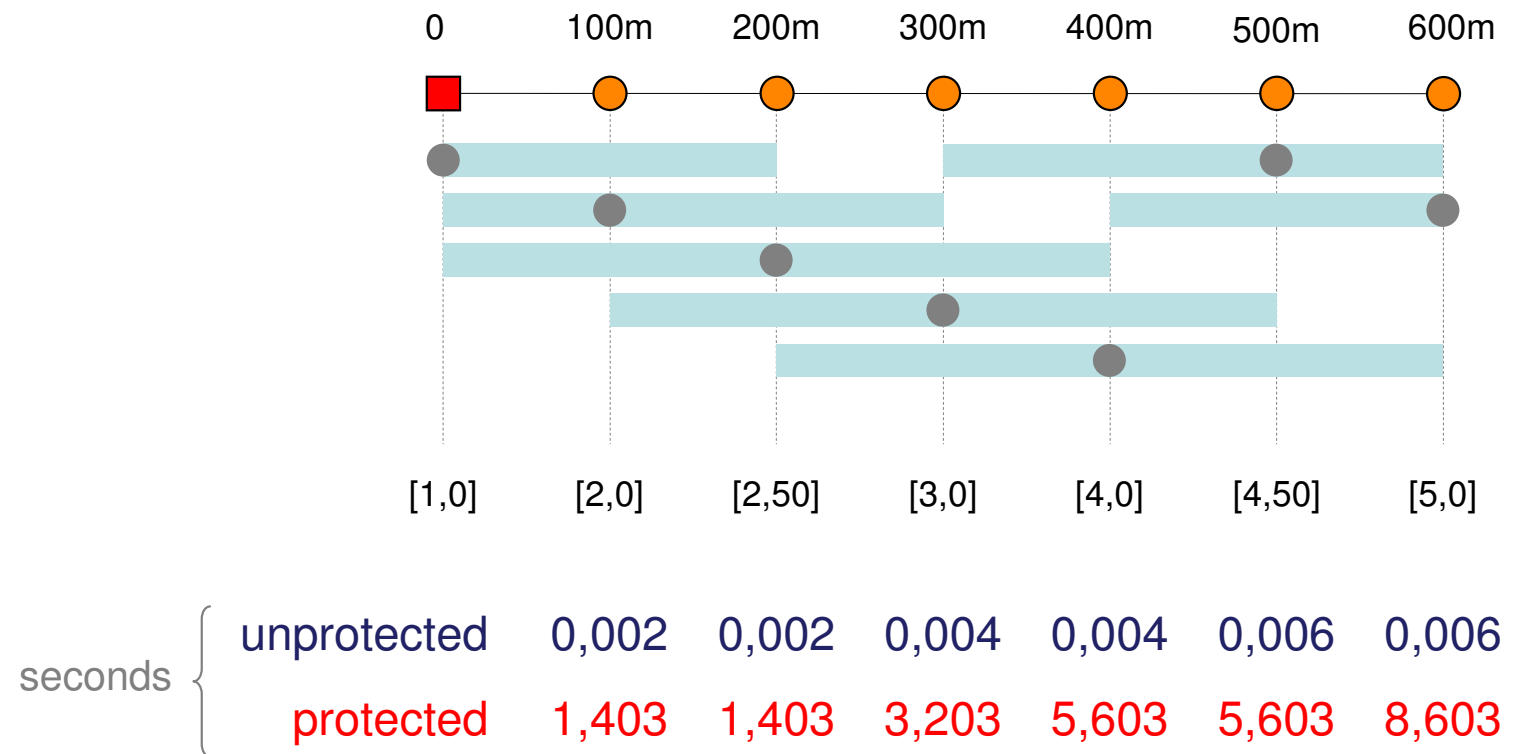


Formal Validation





Numerical Application



$\max_{\text{range}} = 200$