

BitSimulator, an electromagnetic nanonetworks simulator

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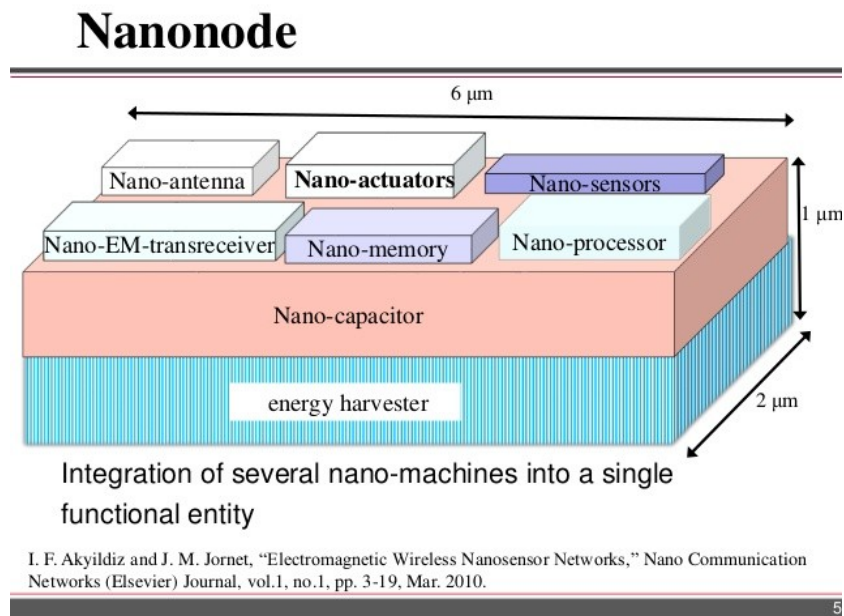
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<http://eugen.dedu.free.fr/bitsimulator>

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THz wireless nanonetworks

Nanonetworks = wireless communicating nanomachines



Complete machine of μm size

- Small communication range: \sim cm
=> Need multi-hop for longer comm distances
- Nanonodes have not yet been built because of technological challenges
=> Need to develop simulation tools
- Nanonodes have unusual characteristics:
 - specific modulation (TS-OOK)
 - specific collisions
 - ...

TS-OOK

- To send bits "1" sender sends pulse, while for bits "0" a silence is used
Pulses are very short (e.g. ~100 femtoseconds)
- Pulses from a given frame are spread over a period much bigger than the pulse duration (e.g. 1000 times longer)
This high spreading ratio makes frames from different communication overlap

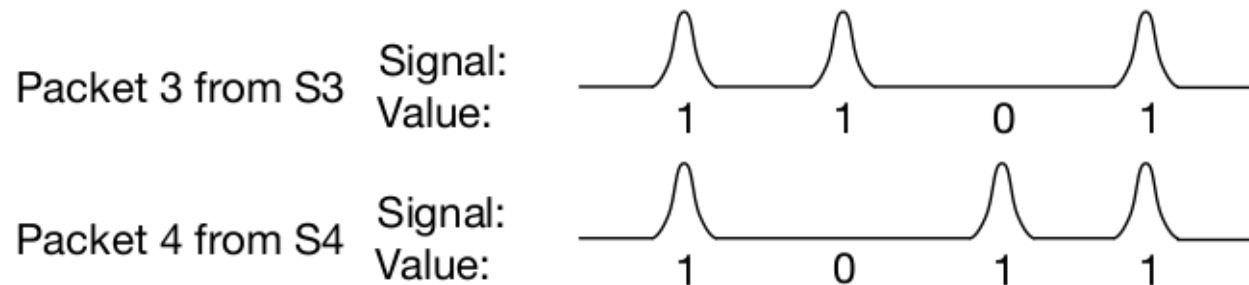


- At this scale, node positions influence the reception date
=> the propagation delay (speed of light) cannot be neglected in studies

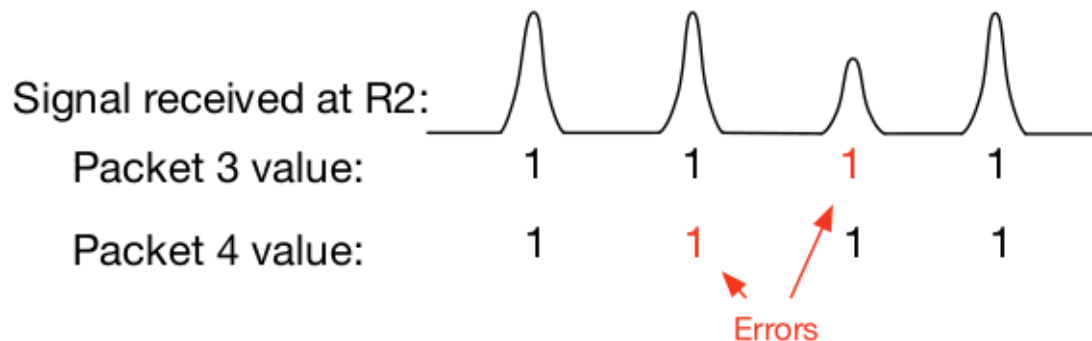
Collisions

Collisions appear when several bits from different frames arrive at a receiver at (almost) the same time

Not all collisions lead to errors; for instance those two frames are sent



The only error occurs when the 1 bit from S3 hides the 0 bit (silence) from S4 at the receiver R2.

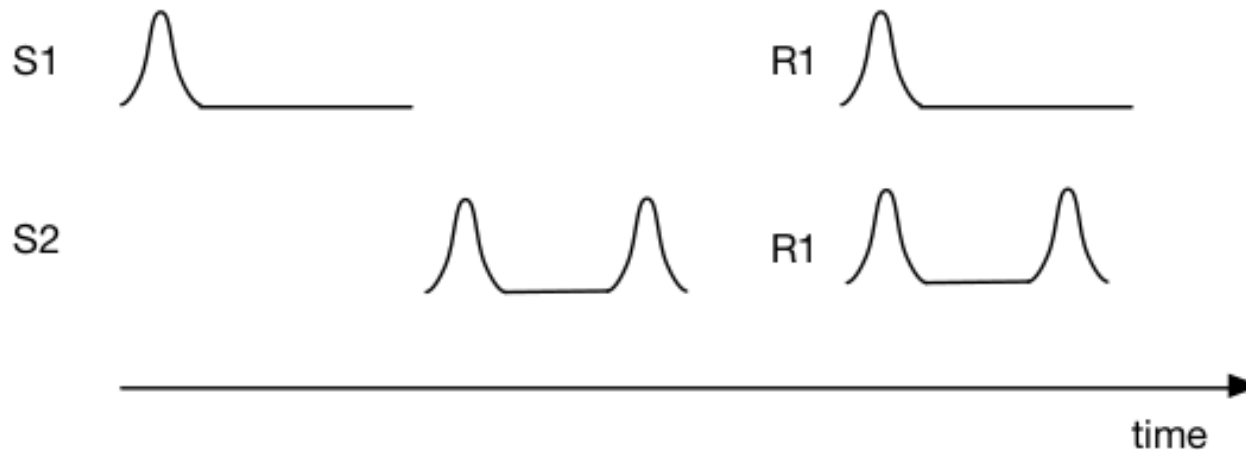


Collisions appear differently on different nodes due to the propagation delay

State of the art

NS3: NanoSim

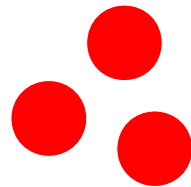
- NanoSim: an NS3 extension
- Do not consider payload and propagation delay is not very precise
=> collisions cannot be correctly computed.



- Cannot handle networks with very high number of nodes

State of the art COMSOL Multiphysics

- COMSOL Multiphysics is a very low level simulator: it can simulate physics behavior
- It is extremely precise
- It is very slow: can take several hours to simulate a scenario with a few nodes. It is useless on scenarios involving huge number of nodes. Our simulator can run scenarios with several thousands of nodes

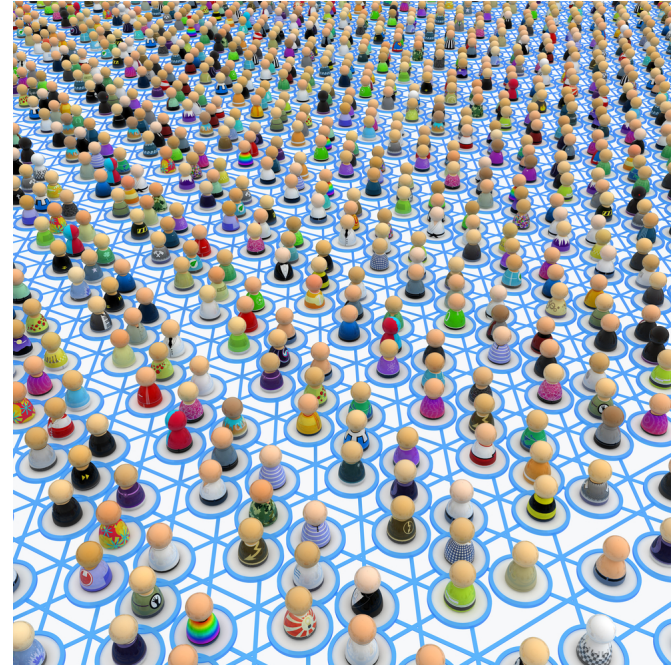


State of the art Vouivre

- Developed by our team
- Simulates a high number of nodes
- Does not take payload into account
- Uses a statistical model to compute collisions on frames
- Very difficult to lead some precise studies (e.g. on bit encoding)

Proposed simulator: BitSimulator

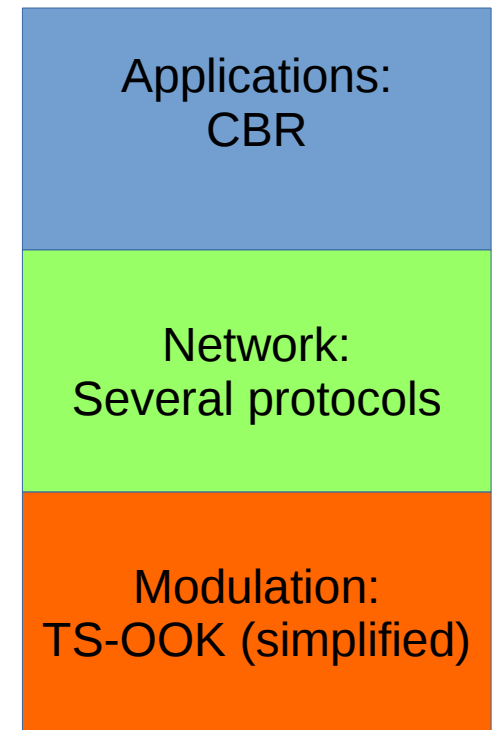
- Specific to nanonetworks
- Discrete event simulator
- Can handle numerous nodes: hundreds of thousands
- Time precision: 1 femtosecond
- Space precision: 1 nanometer
- Simulates each communication at bit level: can compute each collision individually



Implemented features

- Node memory (reception queue) can be configured
- Packet generation: CBR
- General routing protocols: Pure flooding, Probabilistic flooding
- Specific routing protocols: SLR, Backoff flooding, SLR backoff flooding
- Specific network protocol: Density Estimator for Dense Networks (DEDeN)
- Under active development

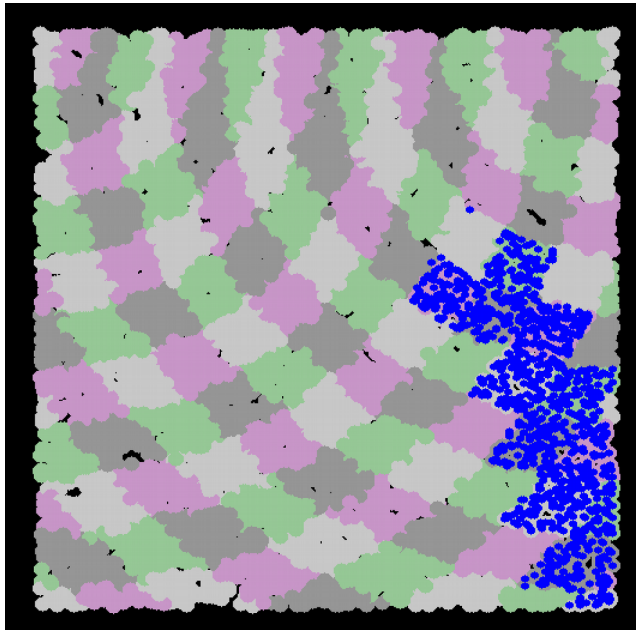
Network layers



SLR / Backoff Flooding

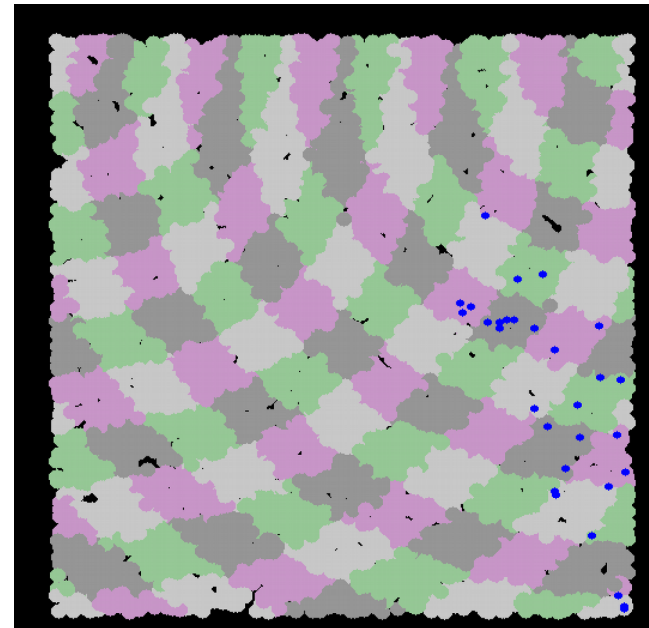
SLR: Stateless Linear Routing

- Designed for nanonetworks
- Geocasting routing using relative positioning



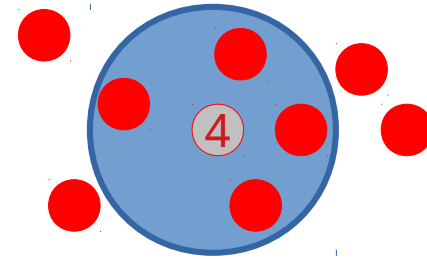
Backoff flooding

- Enhancement of pure flooding that reduce the number of packet sent
- Compatible with SLR



DEDeN

- Density Estimator for Dense Networks
- An algorithm implemented in BitSimulator
- Designed for very dense networks (as nanonetworks can be)
- Can handle very wide range of densities: from few to several thousands of neighbors
- Divided in several rounds with increasing probabilities of sending local probes
Tunable confidence using pre-computed probe threshold
- High performance in terms of estimation error and number of packets generated

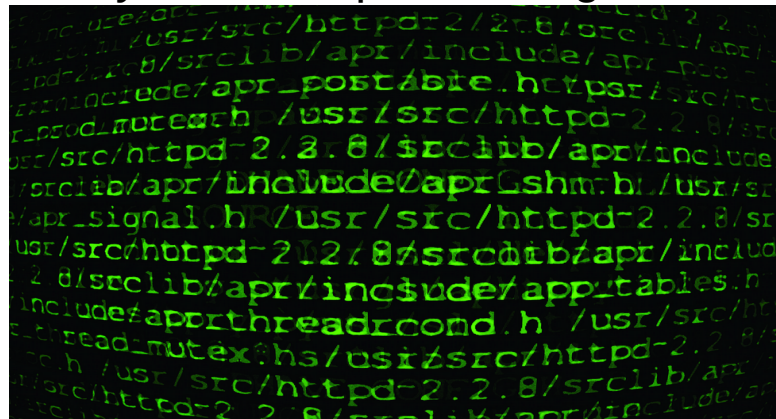


Log system

- Various events are traced during the simulation (receptions, transmissions, collisions, ...)

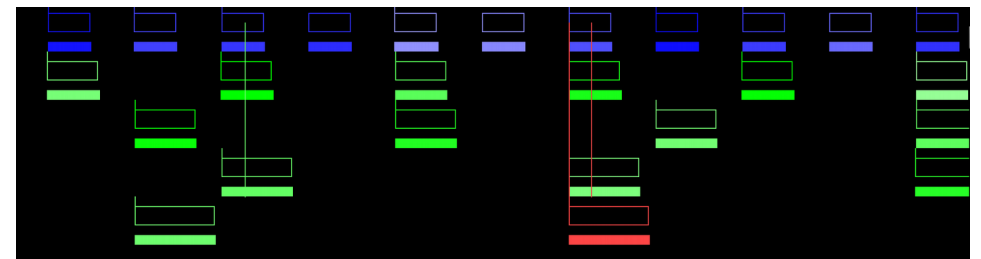
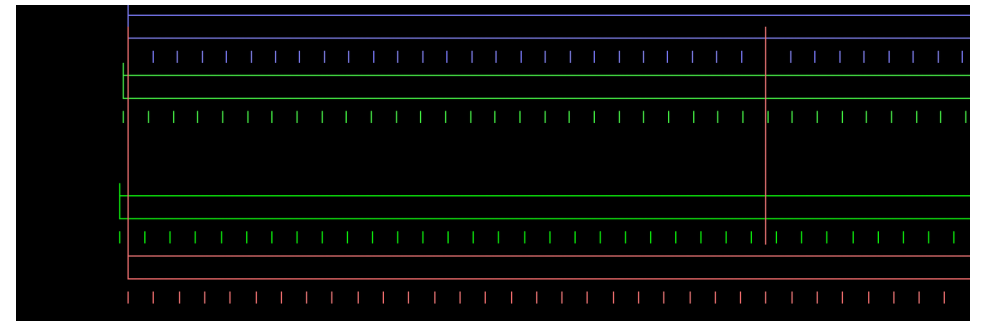
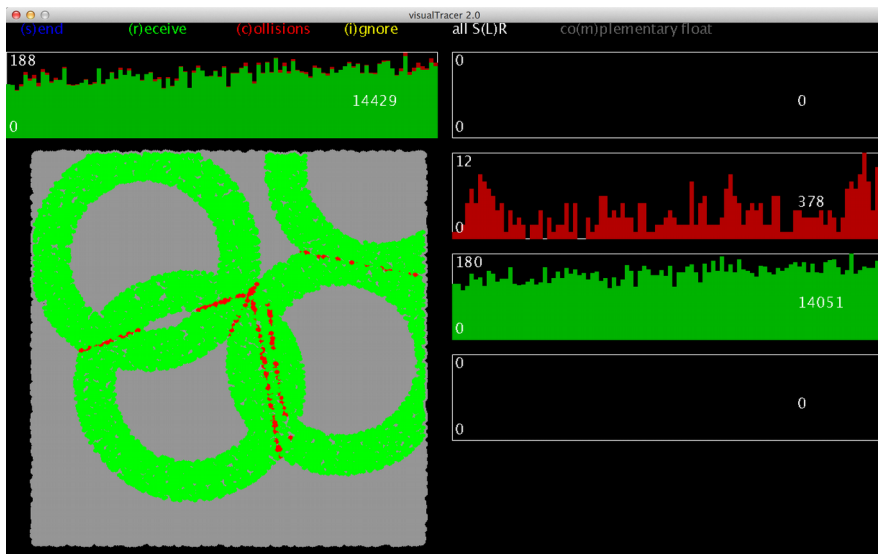
eventType	date(fs)	nodeID	packetType	flowId	sequenceNumber	collidedBits
4(reception)	3900234	2	3(densityInit)	1	0	0

- Easy to add/remove items in log lines
- Easy to add/remove new types of line to trace various information during the simulation
- A log reader library is provided to automatically read and process logs
- Is used by VisualTracer ...



VisualTracer

- Visualization tool for BitSimulator logs
- Shows step by step the propagation of frames through the network
- Separately displays node currently sending, correctly receiving and receiving a corrupted frame (due to a collision)
- Can also follow a node point of view in a chronogram mode



Conclusion

- BitSimulator is fully functional
- Specific to nanonetworks
- Some results have been validated with mathematical models
- The only simulator to treat collisions individually and allow a very high number of nodes
- Allows to test and develop new algorithms and protocols
- Reproducible simulations
- Easy to start with thanks to XML configuration files
- Actively developed
- Free software <http://eugen.dedu.free.fr/bitsimulator>, new contributors are welcome

