Optimizing NDP messages impact on energy consumption in a Small Objects Network IPv6 based

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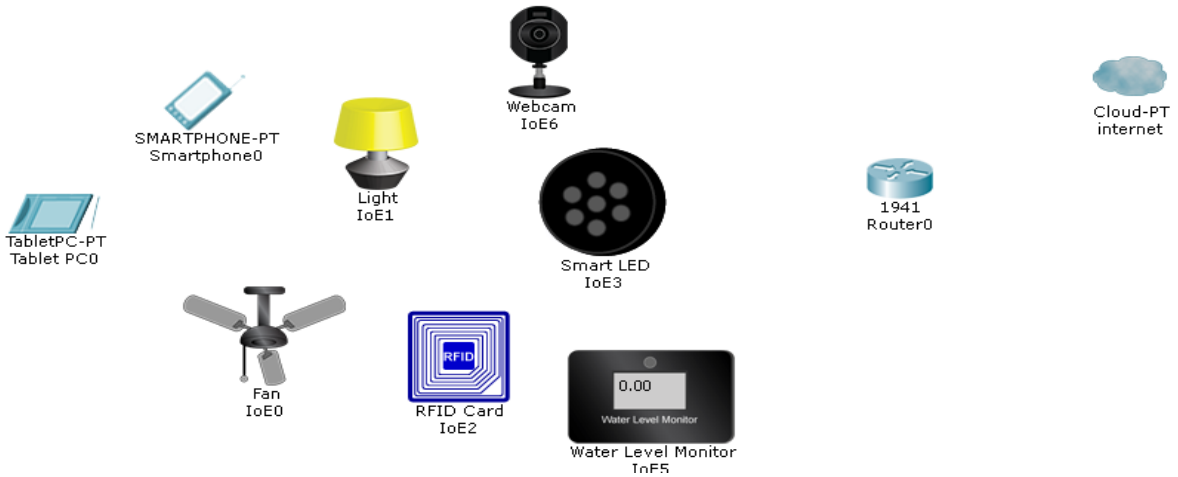
Outline

- Context ;
- Problematic ;
- Related works ;
- Proposal ;
- Results ;

Context

- SmObNet6, Small Objects Networks with IPv6 ;
- Used to define all networks from small as PANs to larger interconnecting small objects ;
- The common point : use IPv6 protocol ;



Problematic

- IPv6 will be the essential network protocol to ensure communication with all objects ;
- IPv6 requires many objects exchanges like :
  - IPv6 routing information ;
  - Multicast communications ;
- The energy consumption becomes one of the most important issues in Small Object Networks with IPv6 (SmObNet6) ;

Related works

- Minimizing energy consumption for WSN by improving Leach routing algorithm ;
- Using NAV method as an extension of the fragmentation mechanism to reduce energy consumption and collisions in IEEE 802.15.4 networks ;
- An Adaptive Mobility Aware and Energy Efficient MAC Protocol for Wireless Sensor Networks :
  - MEMAC allows only nodes that have data to send to be included in the schedule which increases the energy efficiency of the protocol ;

Within IETF works

- 6Lo IETF WG defines specifications for IPv6 over constrained node networks comprising such as :
  - Limited power, memory, and processing resources ;
  - Hard upper bounds on state, code space, and processing cycles ;
  - Optimization of energy and network bandwidth usage ;
  - Lack of some Layer 2 services, such as complete device connectivity and broadcast/multicast ;

Proposal

- Suggest a new method which could reduce energy consumption within Small Objects networks IPv6 based ;
  - The performance evaluation is based on several parameters that, by some minor modifications, will reduce objects Energy consumption ;
  - This method is within a new developed algorithm ;

Proposal, principles

- Tacking IPv6 parameters :
  - AdvDefaultLifetime ;
  - MaxRtrAdvInterval ;
  - MinRtrAdvInterval ;
- **K = AdvDefaultLiftime/MaxRtrAdvInterval**
  - The K factor can show how many RAs will be sent in a network by the default router before its router lifetime expires ;
- **Average RA interval = (MaxRtrAdvInterval + MinRtrAdvInterval) /2**
- **RAs/second =Number of Objects / Average RA interval**

Proposal, constraints

- Maintaining IPv6 object connections ;
- Be in conformity with IPv6 standards ;
- Do not impacts other network parameters ;

Proposal, Energy consumption model

- $E_i = p_i * d_i$
- Multicast value of i^{th} multicast session: $v_i = m_i * d_i$
- Average (per call) multicast value per unit energy:

$$V_E = \frac{1}{X}\sum_{i=1}^{X}\frac{v_i}{E_i} = \frac{1}{X}\sum_{i=1}^{X}\frac{m_i d_i}{p_i d_i} = \frac{1}{X}\sum_{i=1}^{X}\frac{m_i}{p_i}.$$

- $\mathbf{n_i}$: Number of intended destinations by ith multicast arrival ;
- $\mathbf{m_i}$: Number of destinations reached by ith multicast session ;
- $\mathbf{d_i}$: Duration of i^{th} multicast session (assumed exponentially distributed with mean = 1)
- $\mathbf{p_i}$: Sum of the transmitter powers used by all nodes in i^{th} multicast session ;
- $\mathbf{E_i}$: Total energy used by ith multicast session ;
- **vi** : Multicast value of ith multicast session ;

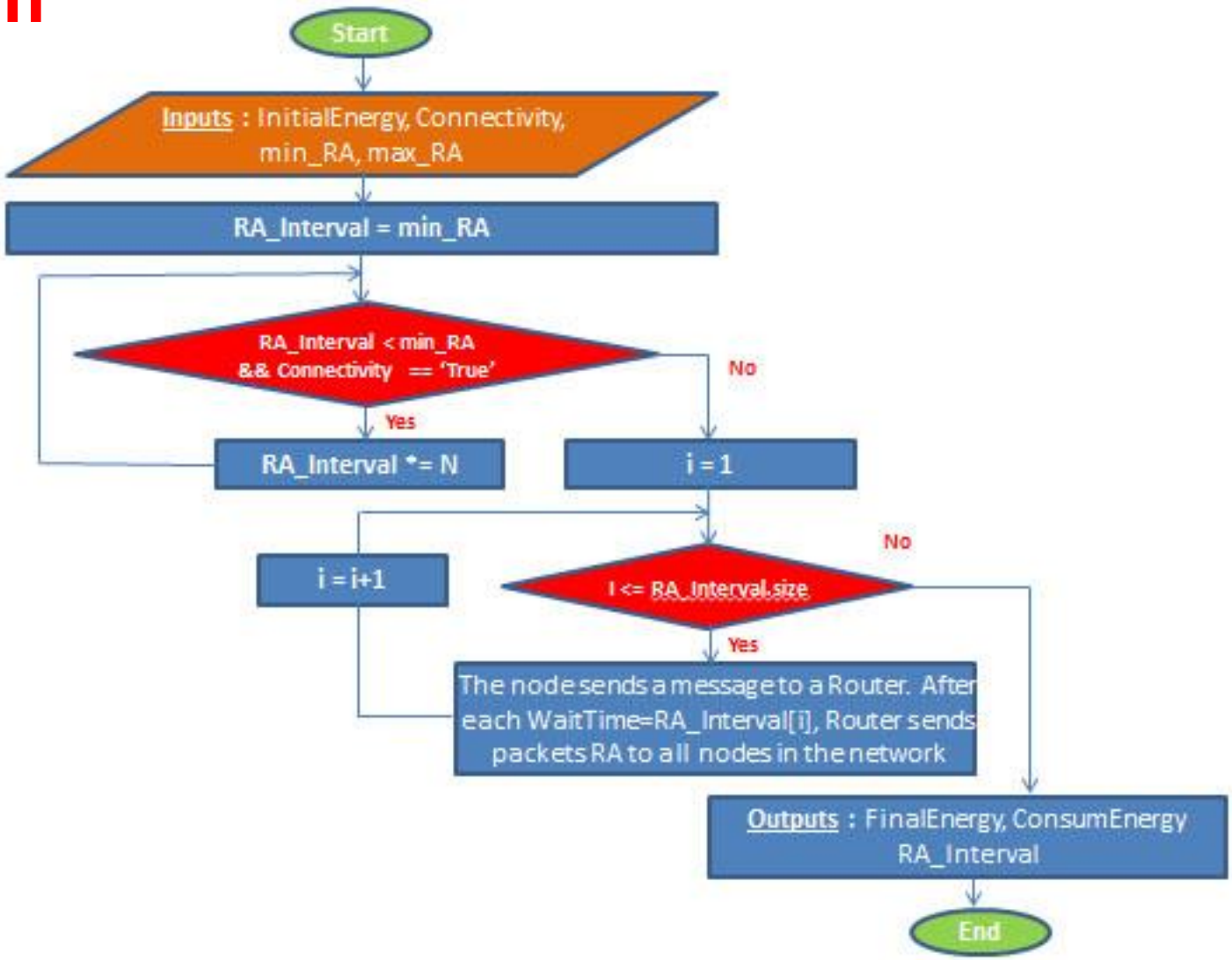
Proposal, Methodology

- Based on the sollicited/unsollicited RAs (Router Advertisements) :
  - Increasing the interval of the periodic RAs is a natural way of further reducing a number of multicast packets in the network ;
  - The router sends unsolicited RAs to advertise its presence to other nodes in an interval defined by MaxRtrAdvInterval and MinRtrAdvInterval ;

Methodology

- A proposed algorithm **OMINSO** (**O**ptimize **M**essages **I**Pv6 based **N**etwork of **S**mall **O**bjects) ;
  - **Inputs**:
    - ✓ InitialEnergy, FinalEnergy;
    - ✓ Connectivity ;
    - ✓ Min_RA ;
    - ✓ Max_RA ;
  - **Outputs**:
    - ✓ ConsumEnergy , RA_Interval ;

Algorithm


Start
Inputs : InitialEnergy, Connectivity, min_RA, max_RA
RA_Interval = min_RA
RA_Interval < min_RA && Connectivity == 'True'
No
Yes
RA_Interval *= N
i = 1
i = i+1
No
I <= RA_Interval.size
Yes
The node sends a message to a Router. After each WaitTime=RA_Interval[i], Router sends packets RA to all nodes in the network
Outputs : FinalEnergy, ConsumEnergy RA_Interval
End

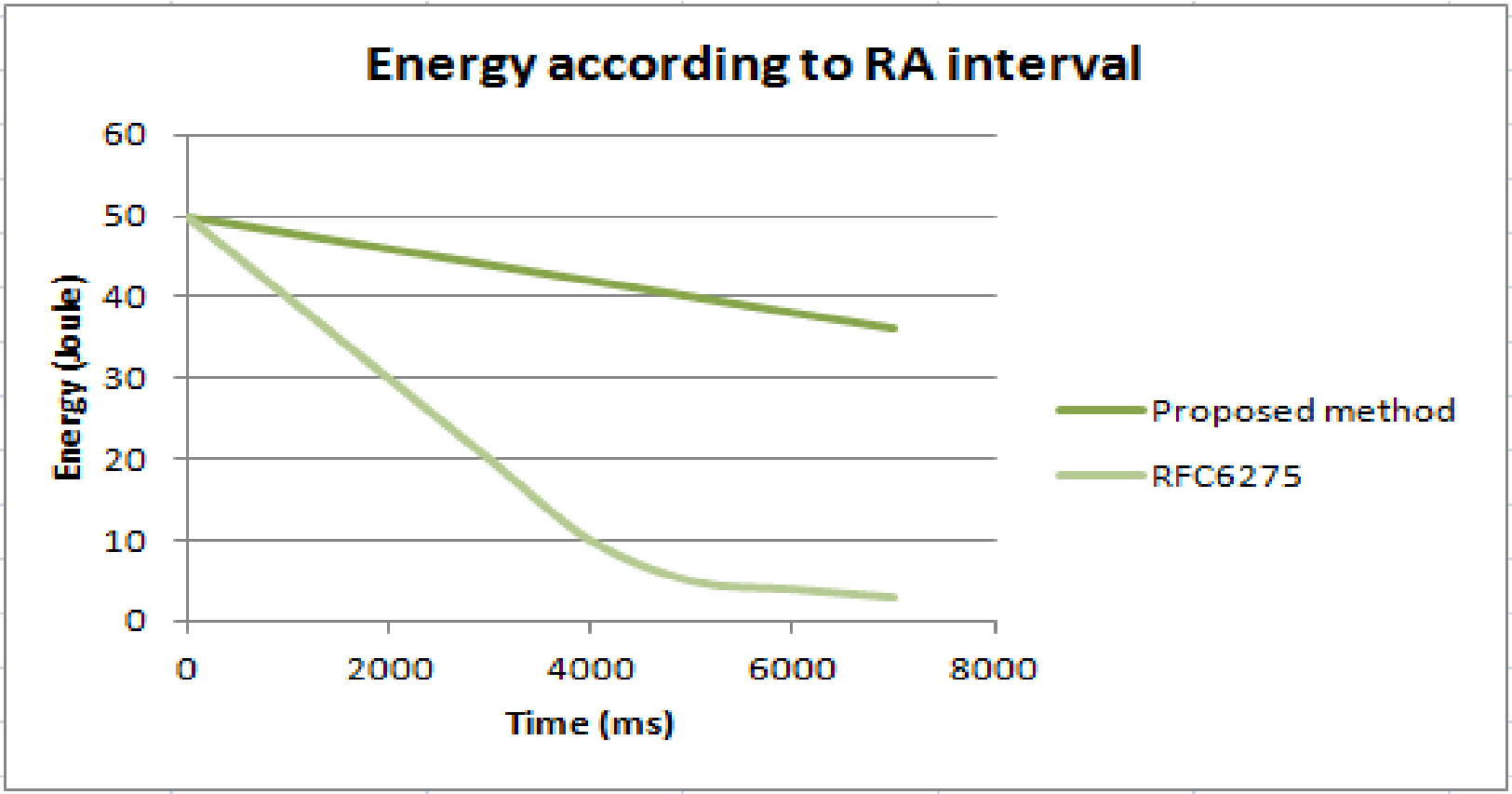
Results

- With adjusting the difference between the MinRtrAdvInterval and the MaxRtrAdvInterval, the periodic RA messages number is decreased ;
- Increasing RA interval reduces the number of RA messages. This could decrease the number of unnecessary signals in the network ;
- By simulation, this optimization does not impact the IPv6 connectivity ;

Results: Energy consumption

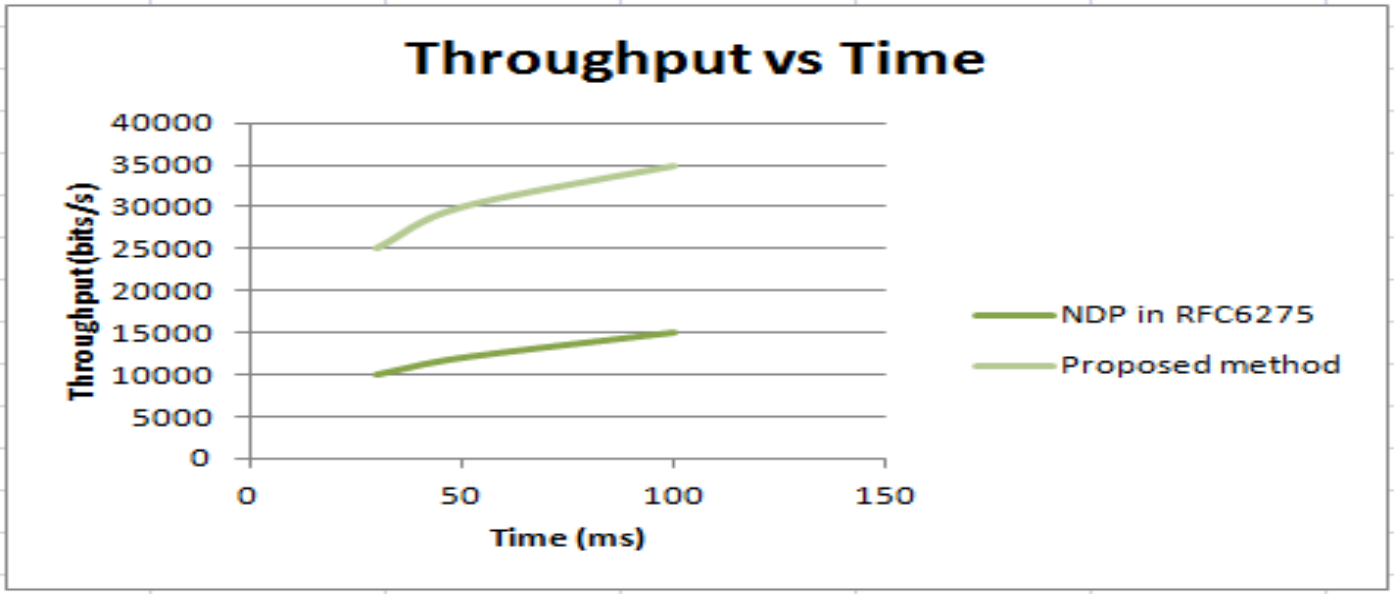
- When considering RA interval in NDP of RFC6275, average energy is 32,11;
  - MinRtrAdvInterval = 0,03 s ;
  - MaxRtrAdvInterval = 0,07 s ;
- When RA interval in [0,3s - 7s], average energy is 48, 36 ;
- We found out that more RA interval is maximized, more the energy consumption becomes lower ;

Results: Energy consumption



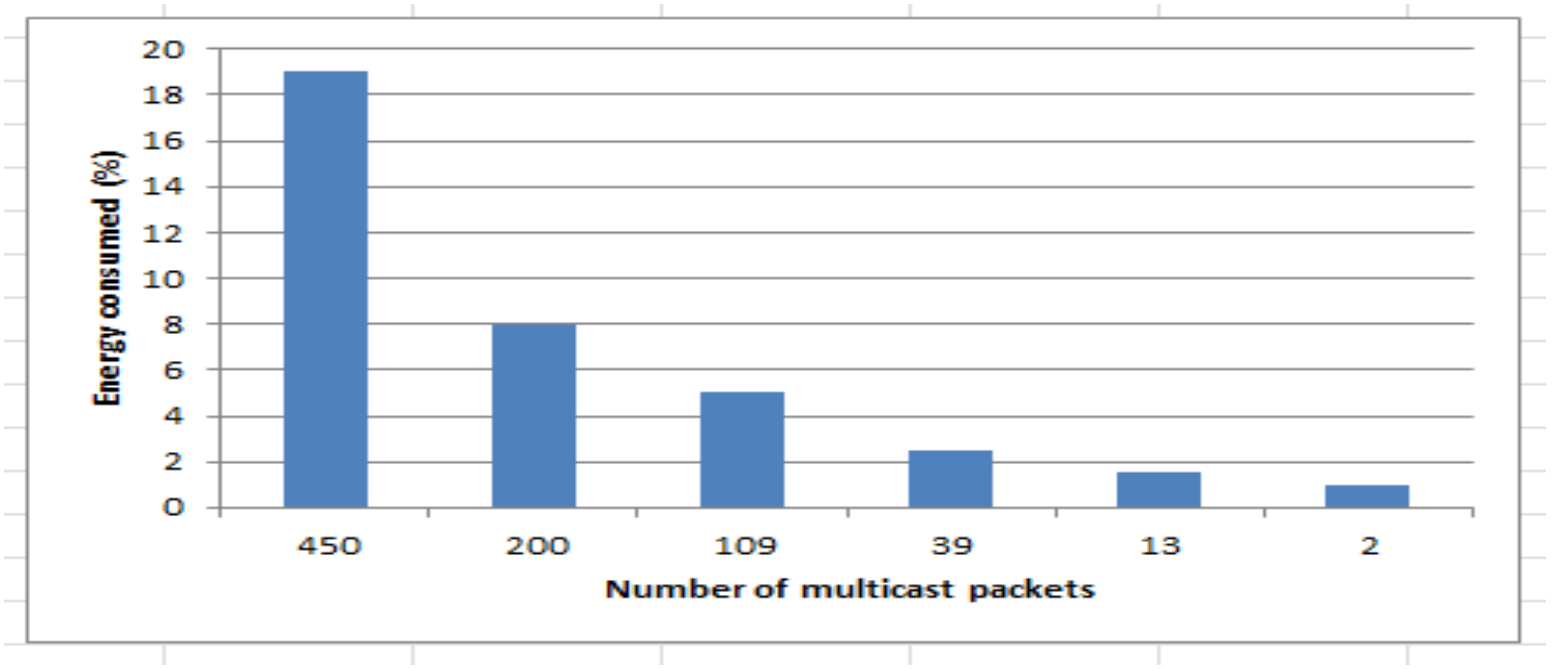
Results: Throughput

- The throughput increases when connectivity is better ;
  - The throughput values of both solutions increase when the RA interval increase and the performance of IPv6 is slightly better than NDP ;



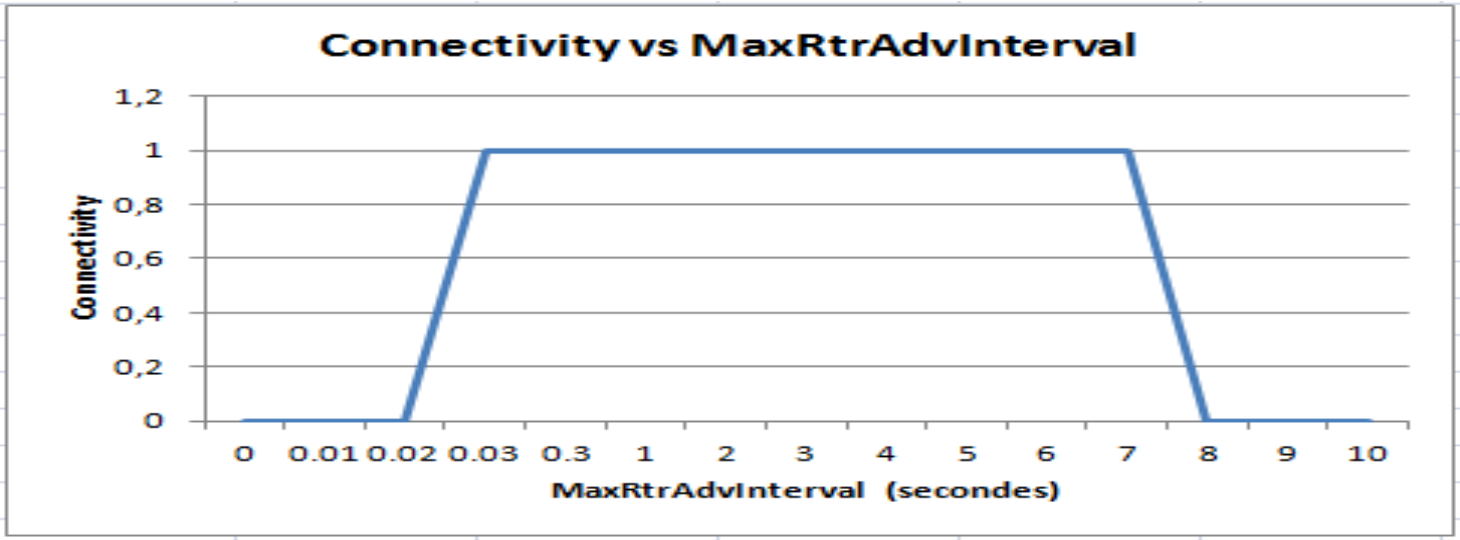
Results: energy consumed vs multicast

- Percentage of energy consumed as a function of the number of multicast packets ;
  - we found in this simulation that the number of multicast packets impacts energy consumption ;



Results: connectivity

- There is connectivity between the mobile node and its correspondent if the value of is ranged between 0.03s and 7s ;
- When the value of MaxRtrAdvInterval is either less than 0.03s or greater than 7s, no connectivity between the mobile node and its correspondent is identified.



Conclusion / Prospects

- We addressed the problem of minimizing the use of NDP messages and the overall energy consumption in IPv6 networks ;
- An optimization issue is realised by some case studies and simulations ;
- An algorithm, called OMINSO, is proposed to minimize energy consumption and maintain the connectivity within the objects in their home network ;

Perspectives

- Try to optimize the RA_interval to find an energy-optimal under the other objects constraints :
  - Mobility ;
  - Security ;
  - Physical ressources ;
  - … ;

Thanks !

Questions ?