IoT4D

Internet of Things for developping countries

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Objectives
Why

Foster Internet of Things technologies

- Developping technologies
  - developping countries
- Useful monitoring
  - environment, agriculture, safety
- Not expansive
  - sensors less 60 K CFA
- Easy to deploy
  - wireless communication

Realisations
since 2016

- 04-05/16 : P.O. Kamgueu invited
  - PhD document
- 08/16 : E. Nataf invited
  - Local deployement at Yaoundé university
- 04-07/17 : P.O. Kamgueu invited
  - Publication in journal
    International journal of Distributed Sensor Network
- PhD defense before end 2017

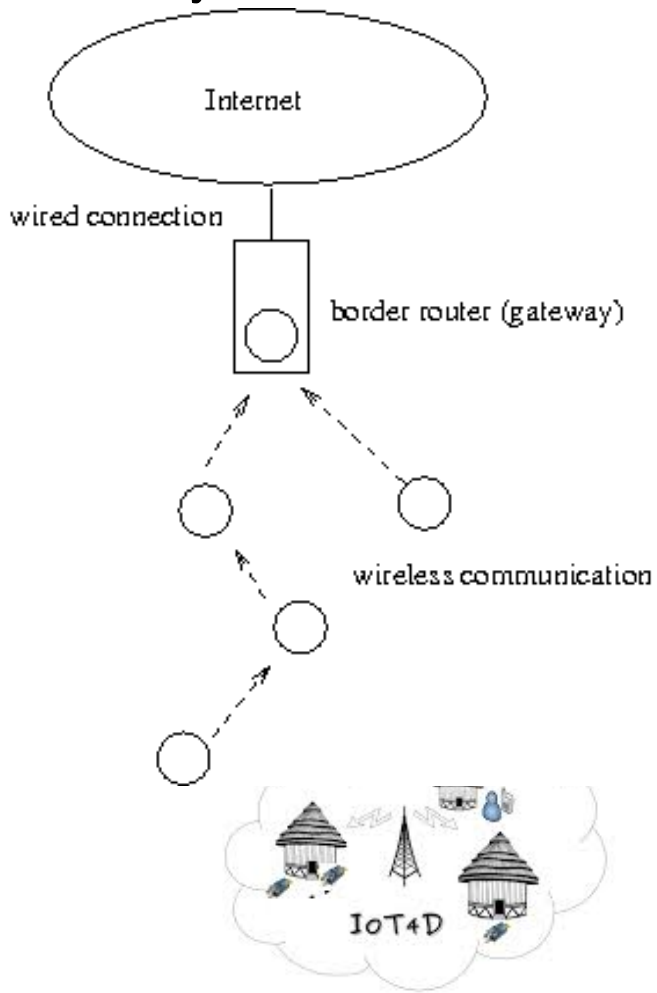
Context
Standardized Wireless Sensors Networks

- Sensor : physical device
  - sensing capability
    - temperature, humidity, motion...
  - CPU
    - low power, low memory
    - powerful enougth to be computational resource
    - OS : Contiki, TinyOS, Riot
  - wireless communication
    - low power (IEEE 802.15.4), low range
    - low throughput (1 Mb)
  - battery powered
    - communication is the most energy drain

Context
Standardized Wireless Sensors Networks

RPL : IPv6 Routing Protocol for Low-Power and Lossy Networks

- Internet standard (RFC 6550 . . .)
- Build an optimal communication network
  - between sensors
  - toward Internet acces point
- Contribution [IEEE SensAPP 2015]
  - optimal based on several metrics
    - QoS, battery, shortest path
  - fuzzy logic design

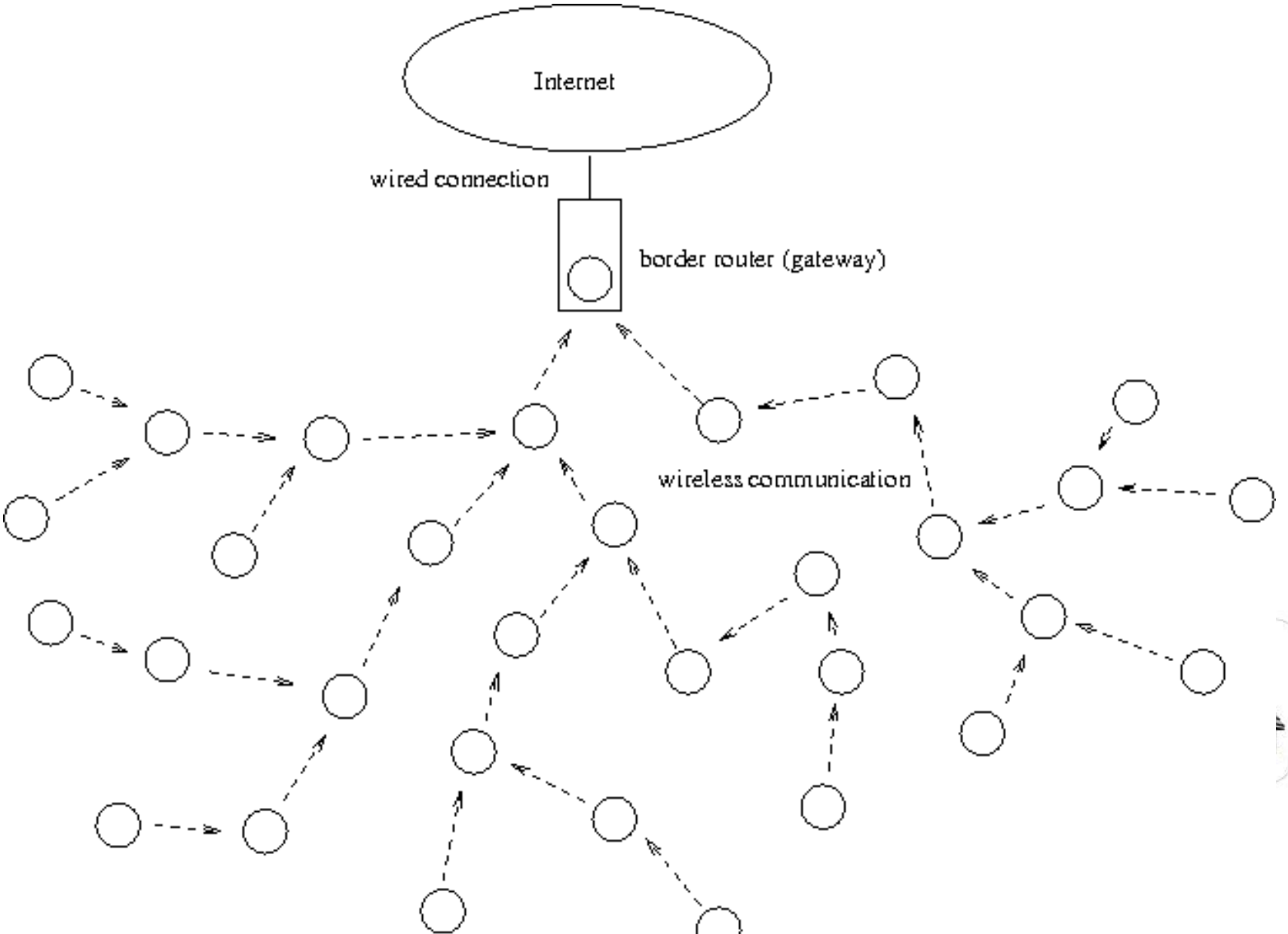


Wide Wireless Sensors Networks

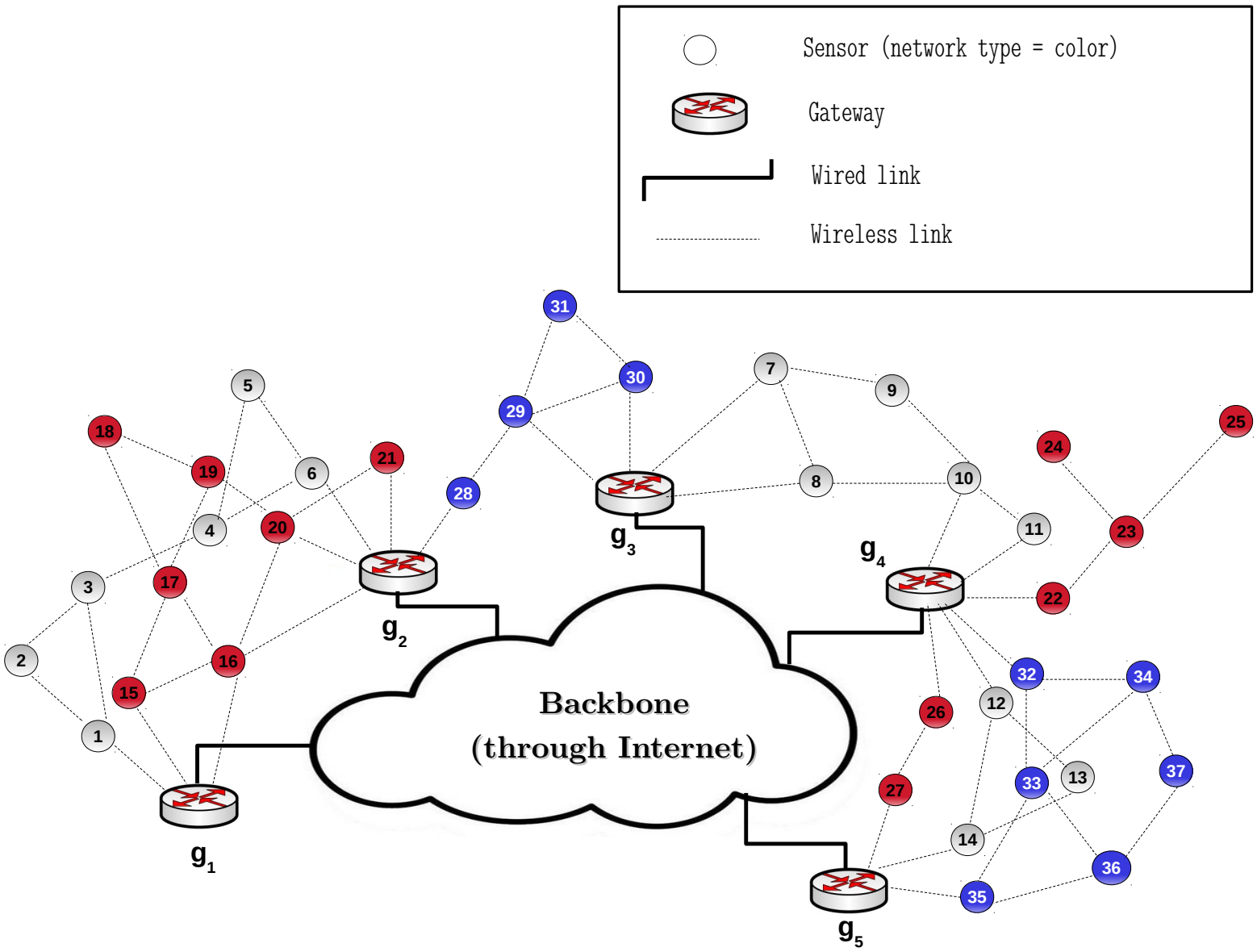
- $\approx$ 100 sensors and more
- Smart city, building, agriculture...
- Several WSN for each
  - smart city
    - temperature, pollution, trafic...
  - agriculture
    - humidity, motion...
- With differents constraints
  - end to end delay
  - lifetime
  - two ways communication

Wide wireless sensors network

Too much for one gateway



Multiple gateways
to multiple wireless sensors networks



WSN vs Gateways
A Capacitated Facility Location Problem

- Each gateway
  - provides Internet access point
  - to several WSN
  - should be available
  - is limited
- Each WSN
  - needs gateways
  - avoid bottleneck
  - could be splitted

Formal description

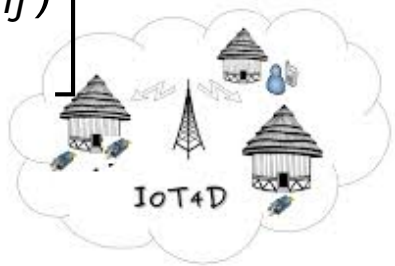
V_g : set of gateways, V_n : set of all WSN sensors

c_{ij} : hops count between gateway i and sensor j

$$X_{ij} = \begin{cases} 1 & \text{if gateway } i \text{ is connected to sensor } j \\ 0 & \text{otherwise} \end{cases}$$

$$Y_i = \begin{cases} 1 & \text{if gateway } i \text{ is open} \\ 0 & \text{otherwise} \end{cases}$$

$$minimize \left[\sum_{i=1}^{|V_g|} \sum_{j=1}^{|V_n|} c_{ij} X_{ij} + \sum_{i=1}^{|V_g|} Y_i + \underset{i \in V_g}{\sigma} \left(\sum_{j=1}^{|V_n|} X_{ij} \right) \right]$$



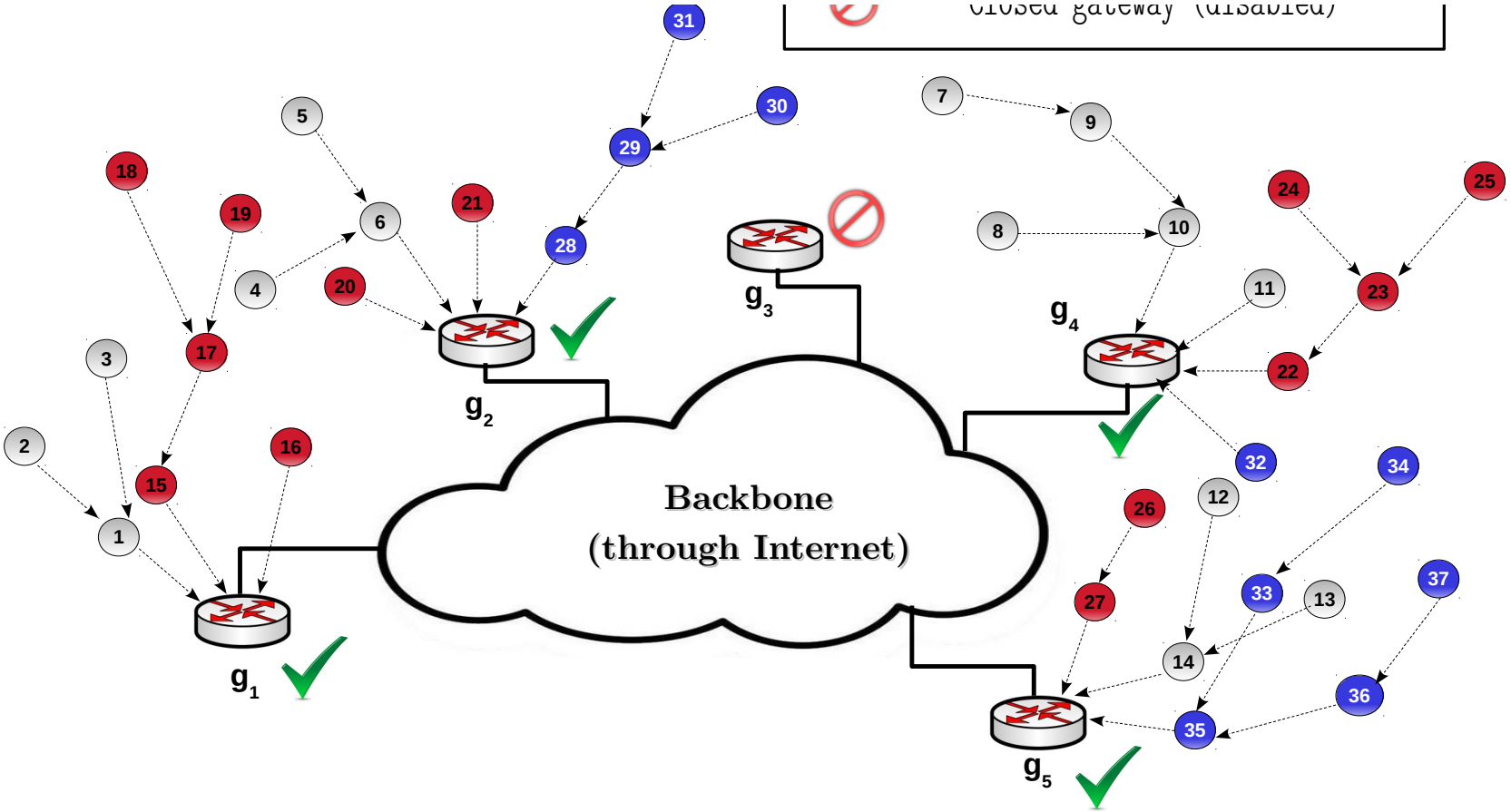
Subject to :

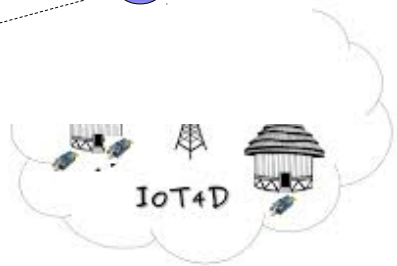
$$
\begin{cases}
\sum_{i=1}^{|V_g|} X_{ij} = 1, & \forall j \in V_n \\
\sum_{j=1}^{|V_n|} X_{ij} \leq \alpha_i, & \forall i \in V_g \\
X_{ij} \leq Y_i, & \forall i \in V_g, \forall j \in V_n \\
\sum_{i=1}^{|V_g|} c_{ij} X_{ij} \leq MAX_{Deep}, & \forall j \in V_n \\
0 \leq X_{ij}, Y_i \leq 1, & \forall i \in V_g, \forall j \in V_n
\end{cases}
$$

α_i : maximal capacity of a gateway i (number of sensors)
MAXDeep : maximal deep of a WSN

One solution

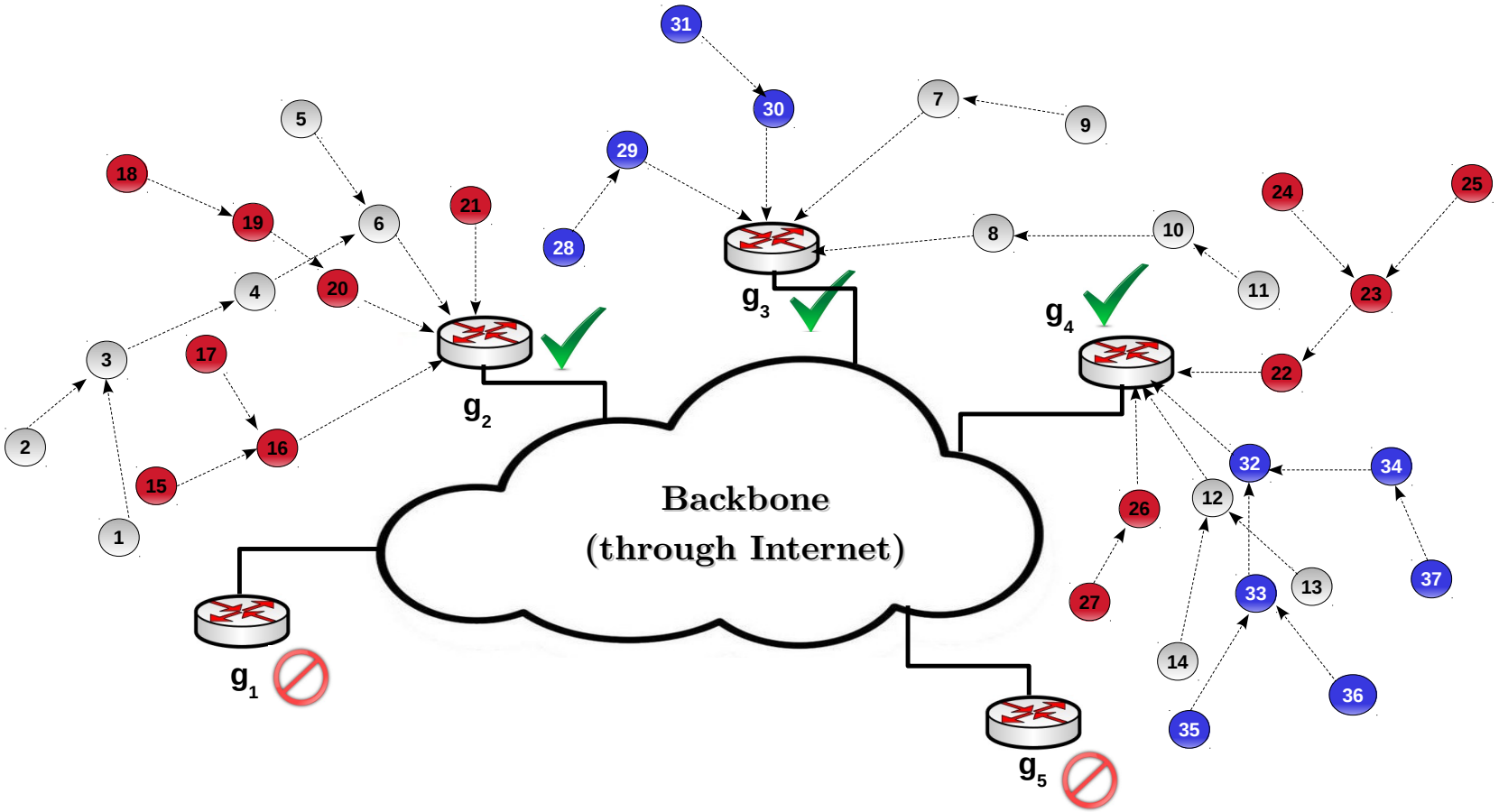
$\alpha_i = 10$

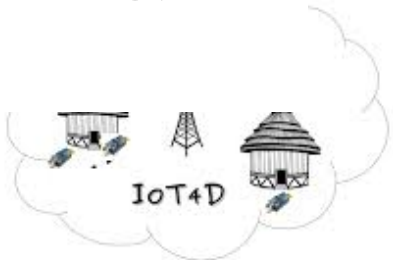




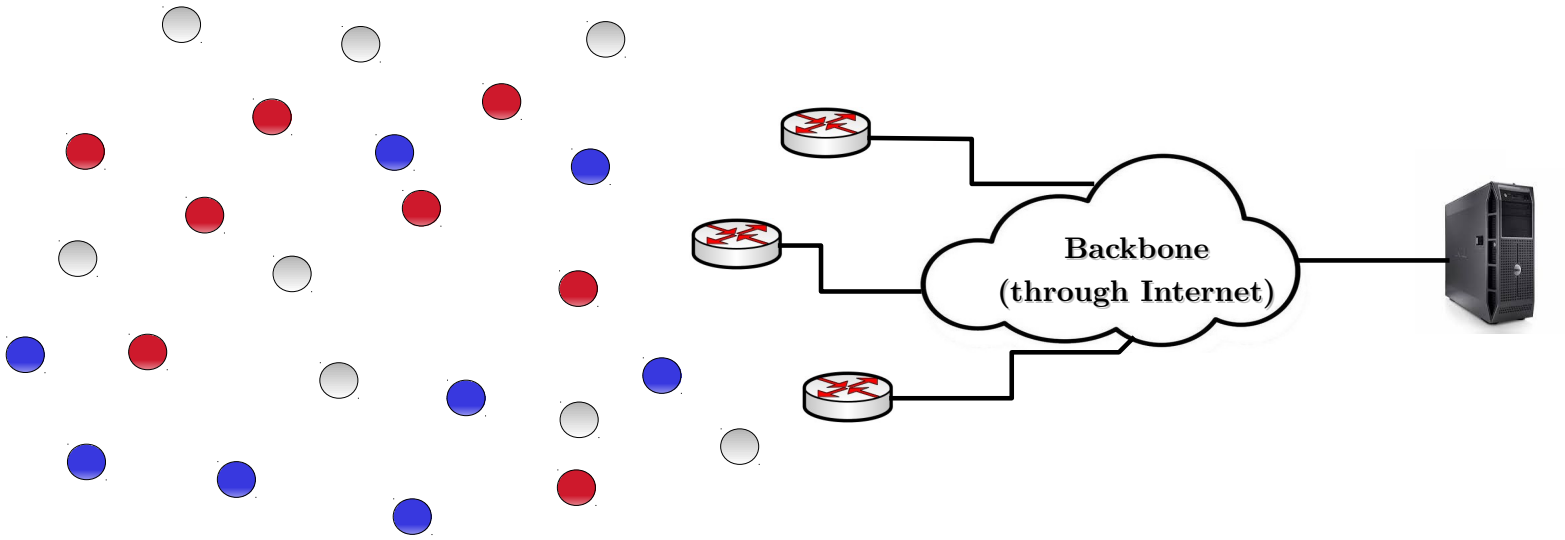
An other solution

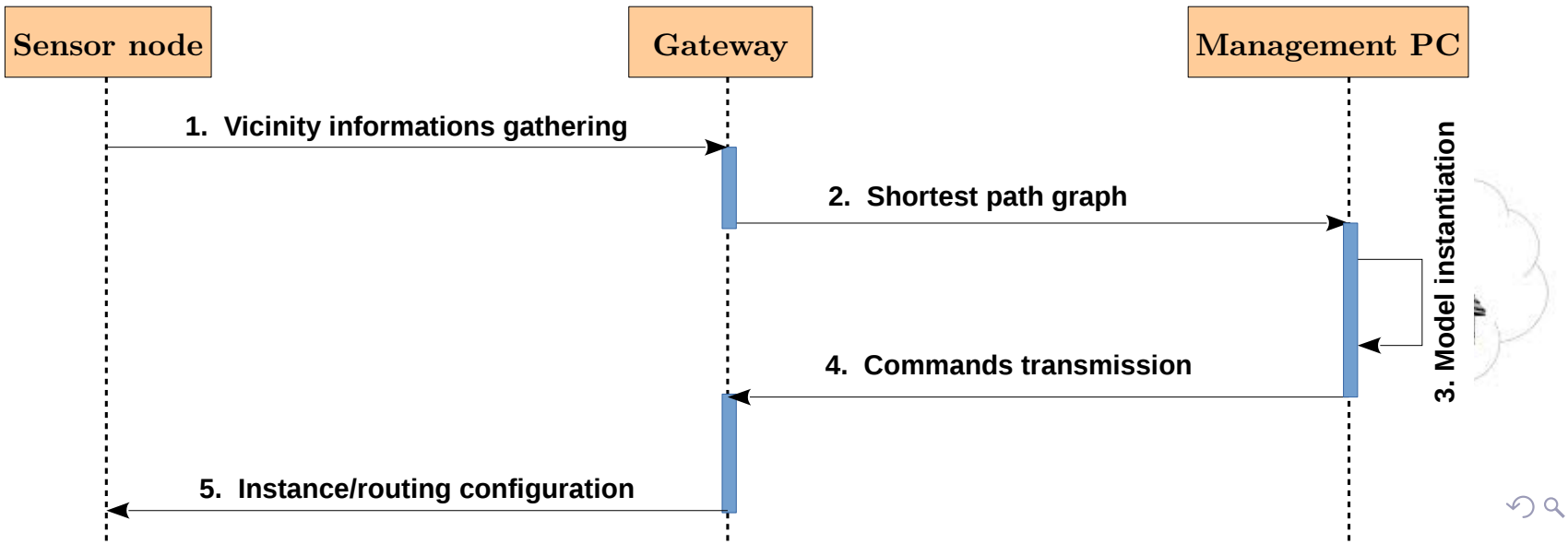
$\alpha_i = 15$





System Architecture



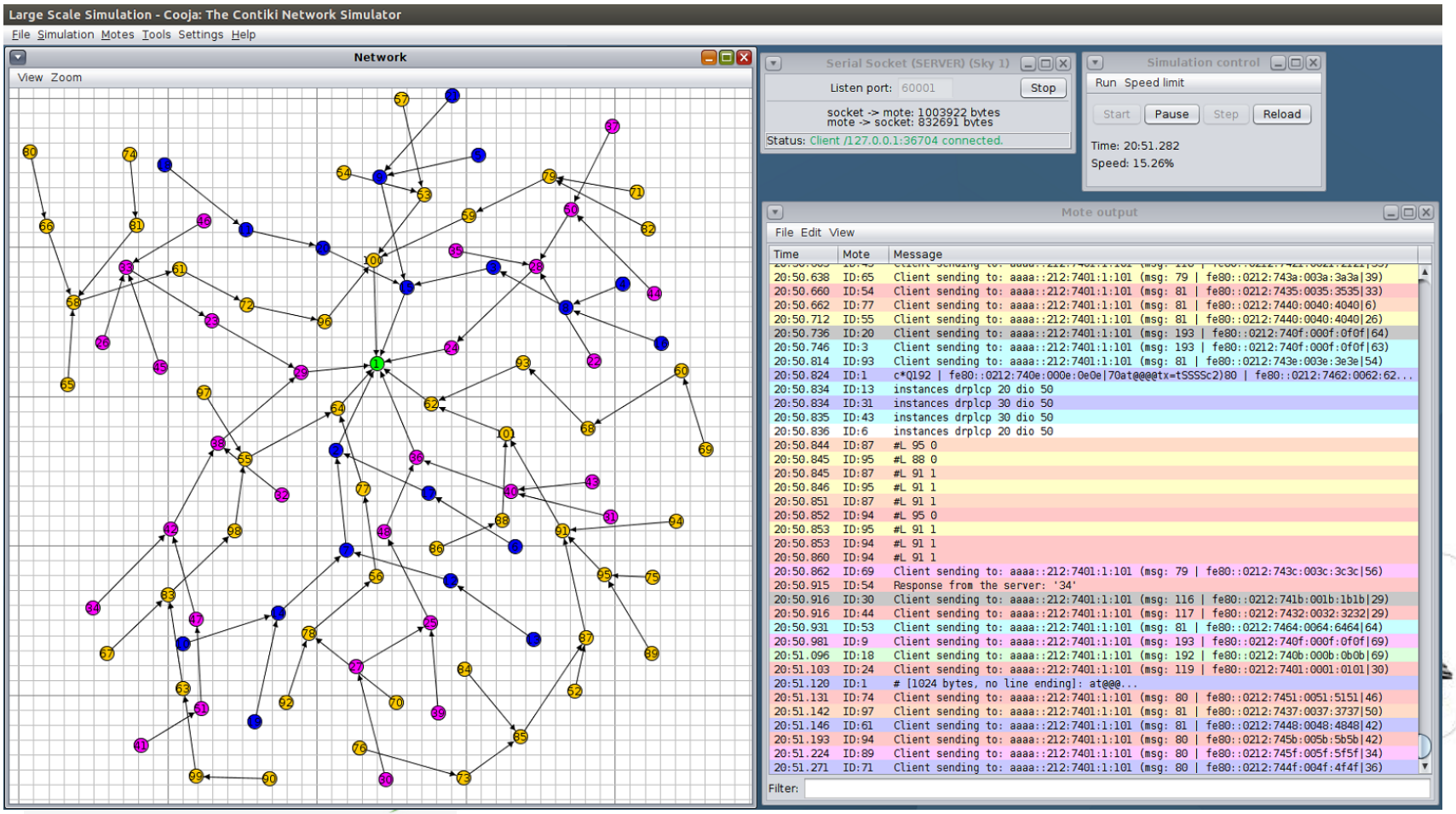


Implementation
6lbr & Raspberry Pi

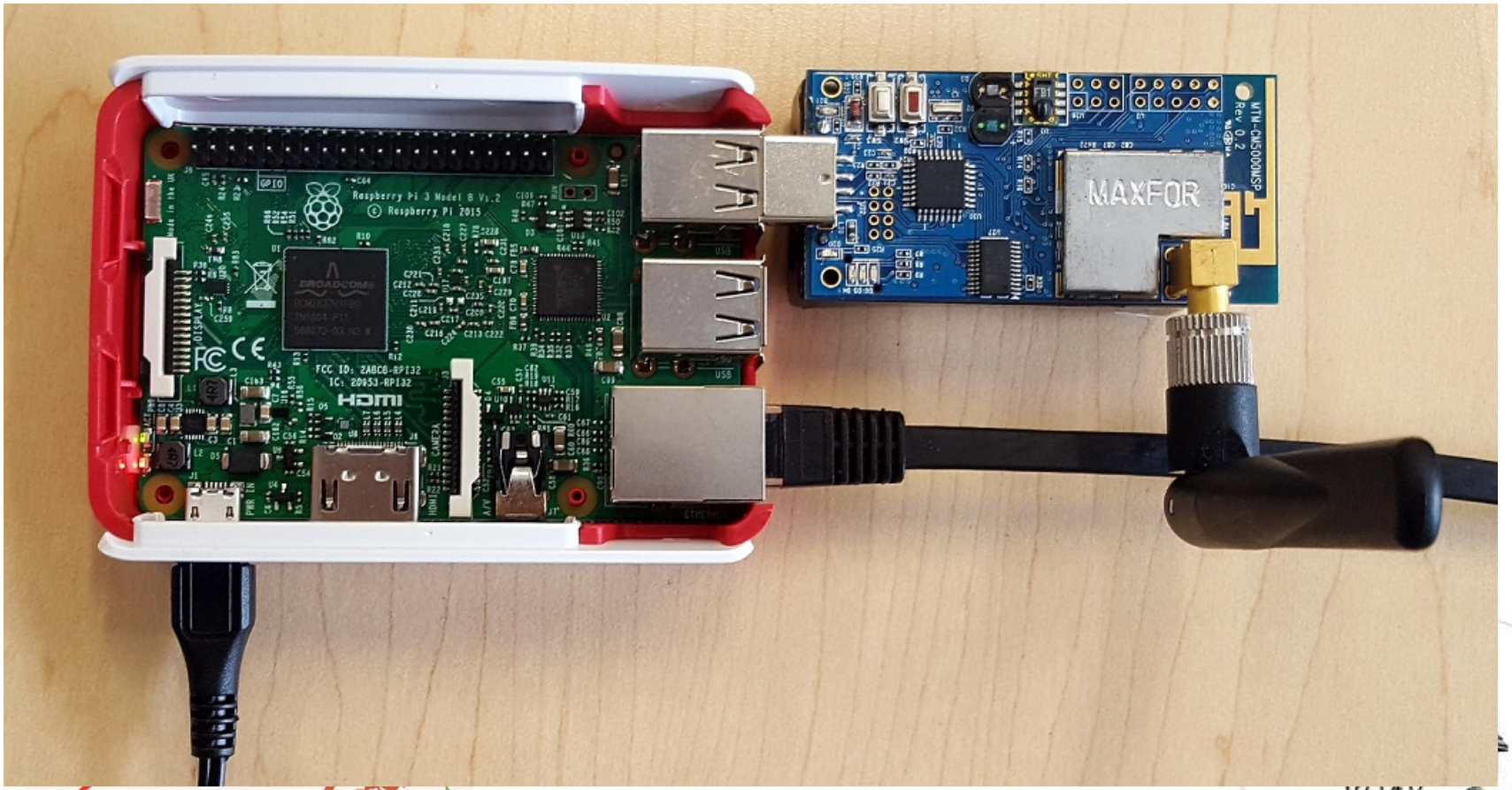
- Fork from CETIC 6lbr open source
- Multiple 6lbr : m6lbr
- Gateway on Raspberry Pi and Sky mote
- Os: Raspbian and Contiki
- Simulation 100 nodes in 3 WSN
- Real deployment with 2 gateways, 5 nodes and 2 WSN

Simulation
Cooja

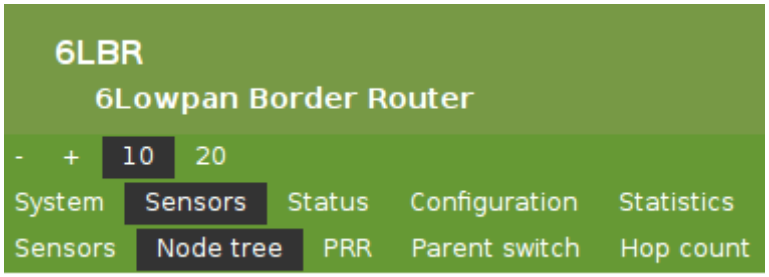
3 separate WSN

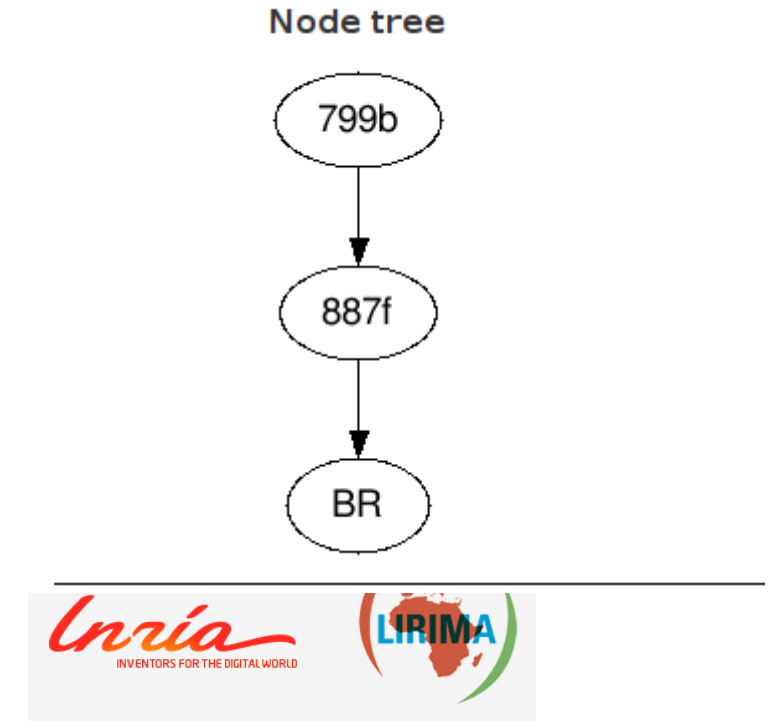


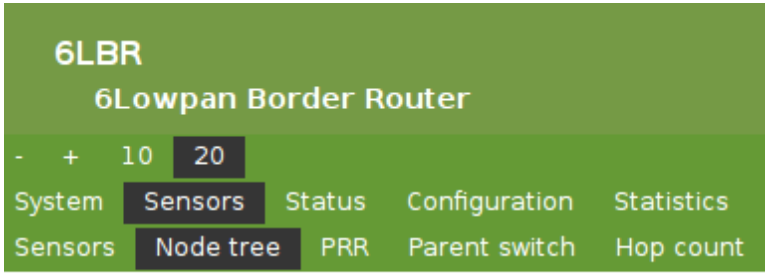
Gateway
Raspberry + Sky

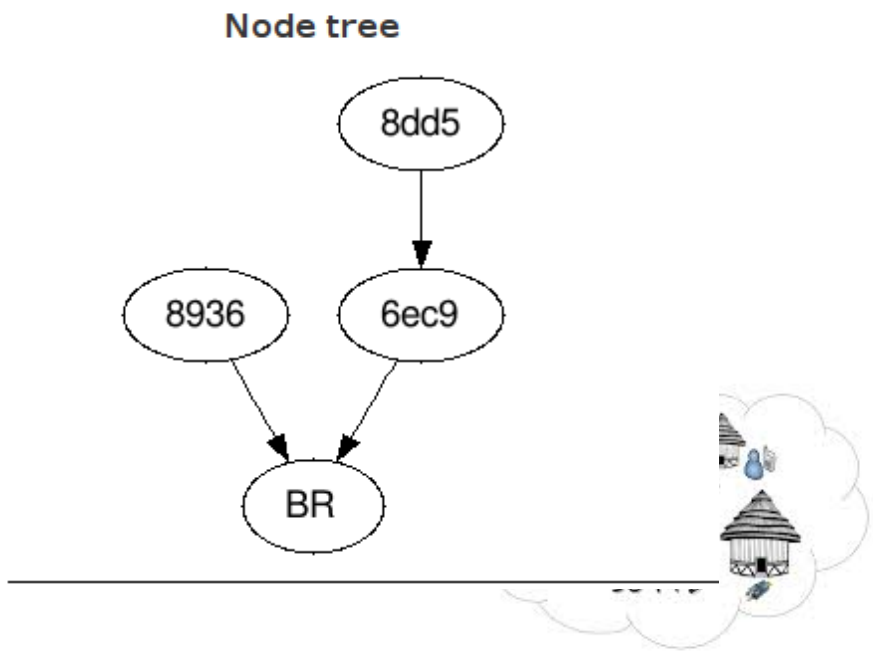


Multiple 6lbr
Web interface





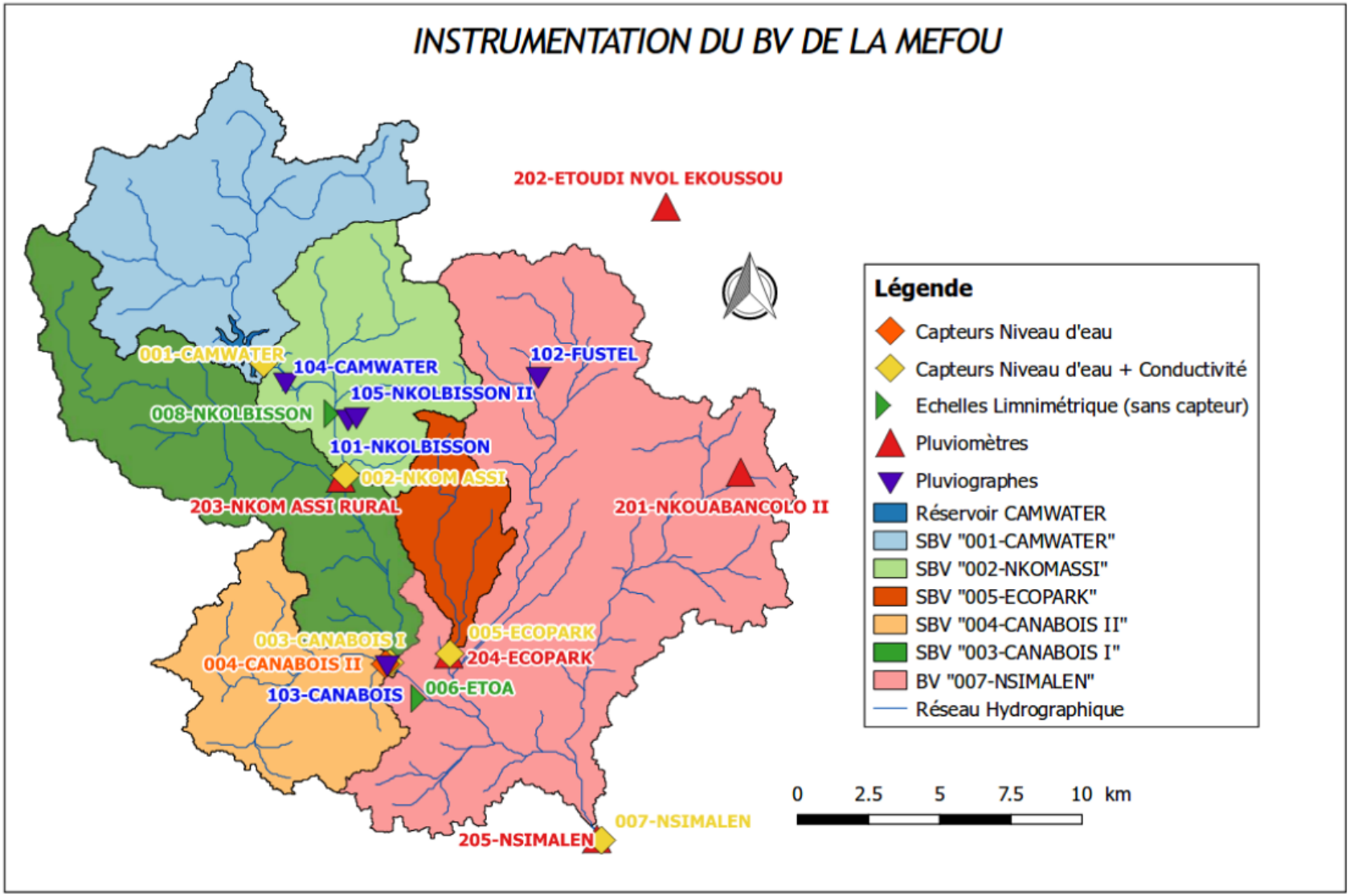




2018 goals
A real project

- IRD works
- Deployement of WSN to monitor water of Méfou
  - rain volumetry
  - water level
  - water temperature
  - water conductivity
- 6 monitored sites
- Manual data gathering

Map

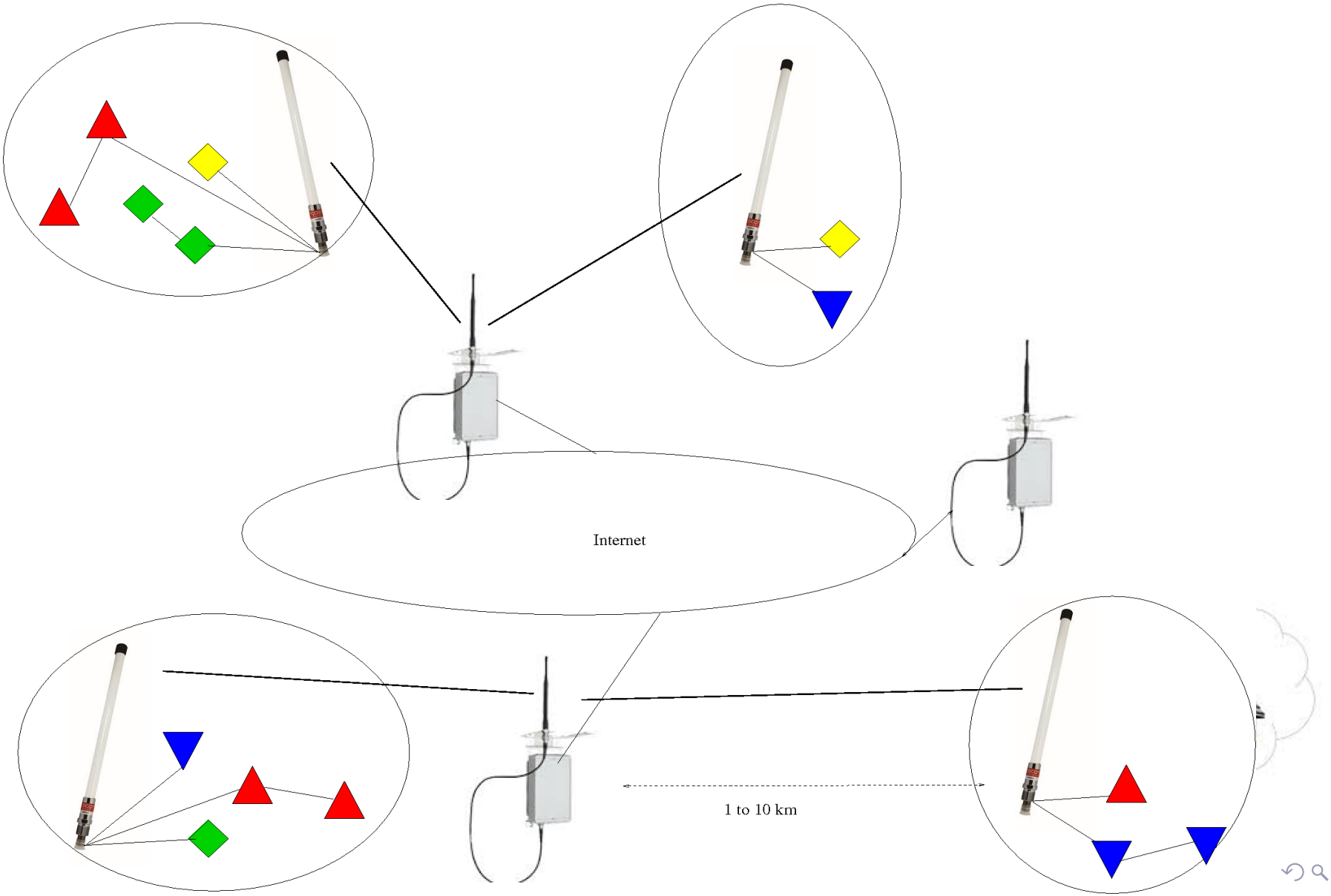

INSTRUMENTATION DU BV DE LA MEFOU
202-ETOUDI NVOL EKOUSSOU
001-CAMWATER
104-CAMWATER
105-NKOLBISSON II
102-FUSTEL
008-NKOLBISSON
101-NKOLBISSON
002-NKOM ASSI
203-NKOM ASSI RURAL
201-NKOUABANCOLO II
003-CANABOIS I
005-ECOPARK
004-CANABOIS II
204-ECOPARK
103-CANABOIS
006-ETOA
007-NSIMALEN
205-NSIMALEN
Légende
Capteurs Niveau d'eau
Capteurs Niveau d'eau + Conductivité
Echelles Limnimétrique (sans capteur)
Pluviomètres
Pluviographes
Réservoir CAMWATER
SBV "001-CAMWATER"
SBV "002-NKOMASSI"
SBV "005-ECOPARK"
SBV "004-CANABOIS II"
SBV "003-CANABOIS I"
BV "007-NSIMALEN"
Réseau Hydrographique
0 2.5 5 7.5 10 km

IoT Backbone

- Data collect automatisation
  - limits human intervention
  - increase accuracy, data volume
- Openness and extendability
- Each site
  - WSN_{temp}, WSN_{hydro}, ...
  - throughputs, frequencies
  - one gateway
    - for WSNs
    - long range communication
- Connected network
  - connected and powered gateways
  - geographical coverage
  - long distance communication

Wireless IoT Backbone

LoRa technology



2018
Planning

- Models gateways to gateways
- Study technologies
  - Raspberry / LoRa connection
  - WSN gateway
- Collaboration with IRD
  - french IRD researcher at Yaoundé for 2 years
  - existing relation with Yaoundé assistant prof.