Delft-Girona

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Delft

BCDS
Broadband Communications and Distributed Systems

GOBIERNO DE ESPAÑA
MINISTERIO DE CIENCIA, INNOVACIÓN Y UNIVERSIDADES

# Network security on applied sciences: Sensor placement and blockchain

*David Martínez*
david.martineza@udg.edu
*https://scholar.google.com/citations?user=fJePaR4AAAAJ&hl=en*

TU Delft

Universitat de Girona

# Network security on SDN

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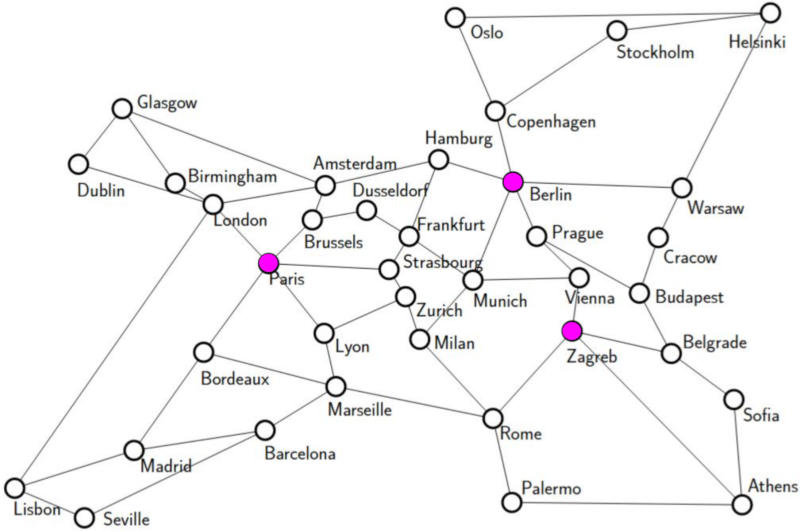
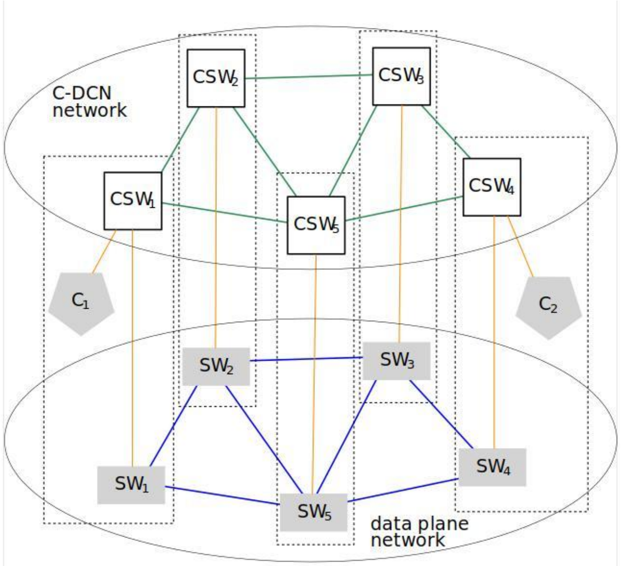
- Is our network **resilient** to attacks or failures?
- The SDN controllers are the most vulnerable assets.

- Where should we place three backup controllers (BCPP)?




cost266 network (topology zoo)




SDN architecture

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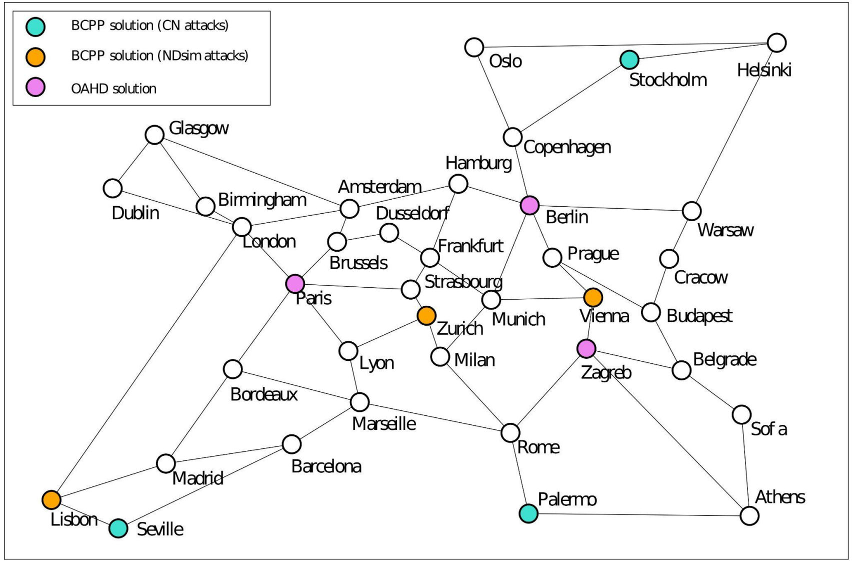


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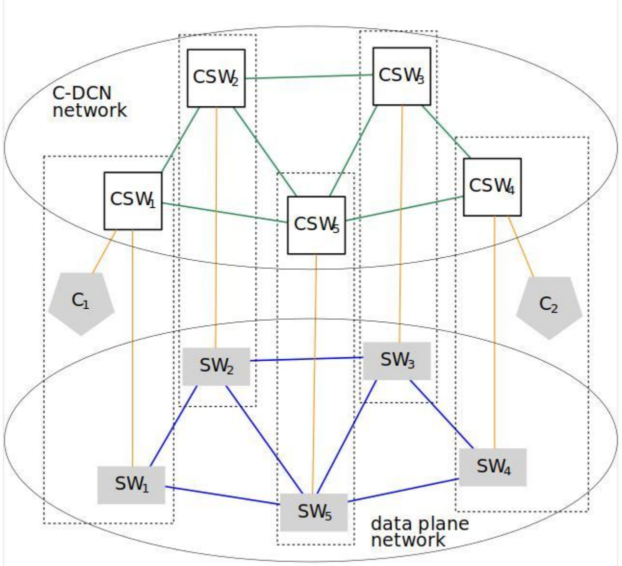


SDN architecture

*Calle, E., Martínez, D., Mycek, M., & Pióro, M. (2021). Resilient backup controller placement in distributed SDN under critical targeted attacks. International Journal of Critical Infrastructure Protection, 33, 100422.*

# Network security on applied sciences

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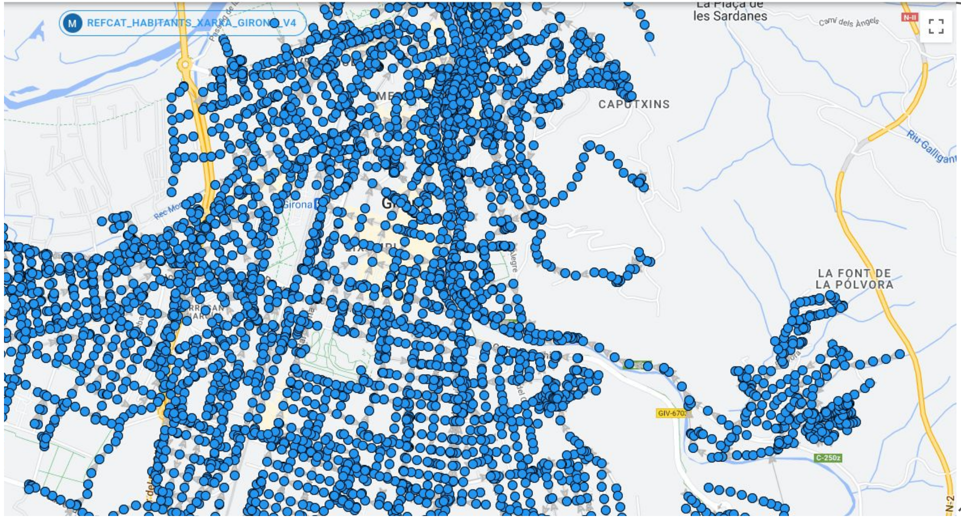
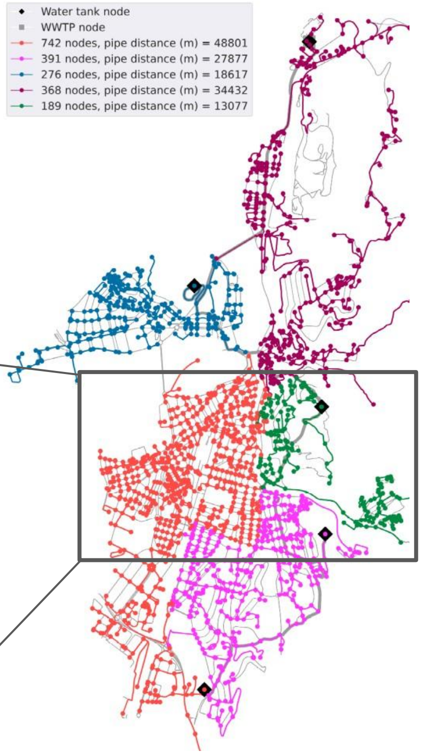
- Security approaches to applied sciences tend to be not such advanced.
- What if we model water networks as a graph? (.graphml)

- With all the necessary information, we can explore algorithms to improve and automate water network designs, sensors placement, blockchain, AI, security frameworks …



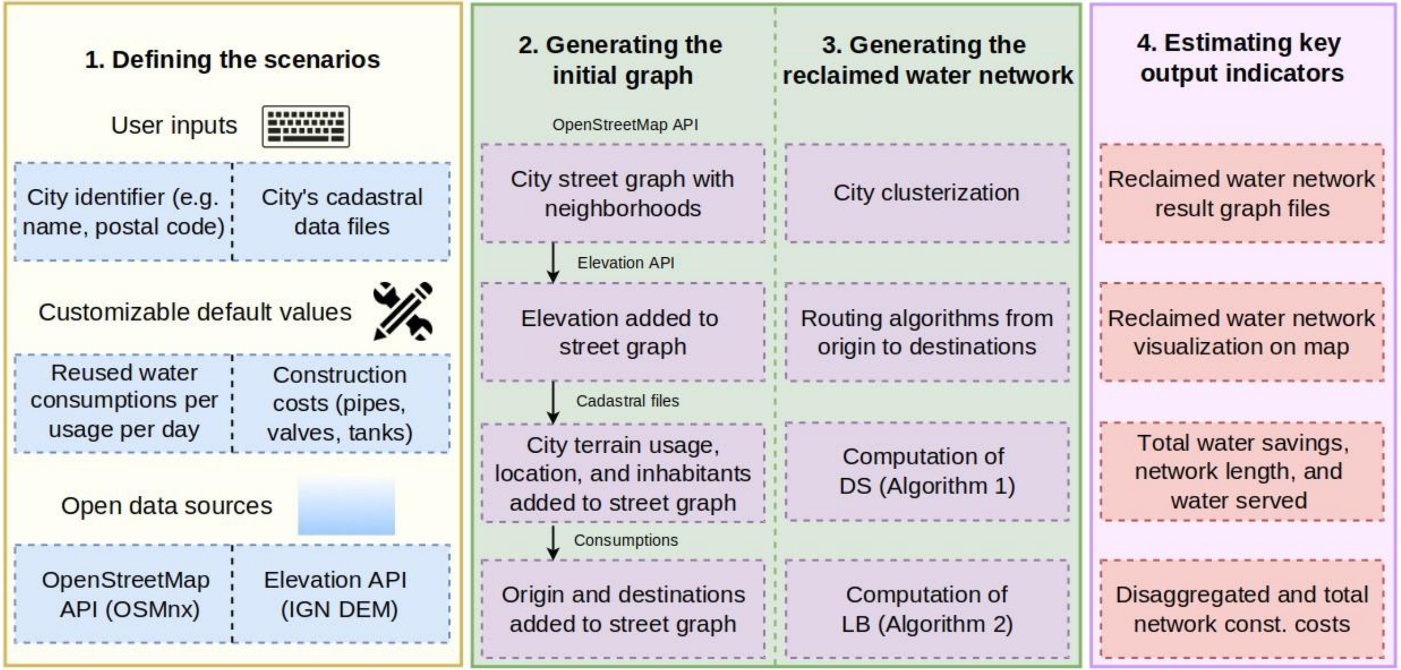

Modeled Girona Wastewater Network




Designed Girona
Reclaimed Water Network

# Water network modeling (reclaimed water)

- Framework/tool for water network modeling: modular design.
- With very few user inputs, it is able to model a water network as a graph with associated information on nodes (pipe intersections, valves, origin, or destination nodes) and edges (pipes).




Network modeling module (Reclaimed water network)

# Algorithms (reclaimed water)

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- Diameter Selection (DS) algorithm: Proper diameter selection for each pipe (edge).
  - The final construction costs are calculated based on the required pipes.

| | |
|---|---|
| $r, r \in \mathcal{V}$ | reclaimed water source node |
| $\mathcal{C}$ | set of water distribution consumption nodes; $\mathcal{C} \subseteq \mathcal{V}$ |
| $\mathcal{D}$ | set of available pipe diameters (each one in mm) |
| $s$ | float constant indicating the desired water flow speed (in m/s, 1 by default) |
| $m(c), c \in \mathcal{C}$ | integer indicating the consumption of destination node $c$ (volume, in $m^3$) |
| $\mathcal{E}(a, c), c \in \mathcal{C}$ | set of edges forming the shortest path from the source node $a$ to the destination node $c$; $\mathcal{E}(a, c) \subseteq \mathcal{E}$ |
| $l(e), e \in \mathcal{E}$ | float indicating the length the edge $e$ (in m) |
| $w(e), e \in \mathcal{E}$ | float indicating the water flow of the edge $e$ (in $m^3/s$) |
| $\mathcal{X}$ | set of edges with assigned water flows; $\mathcal{X} := \{e : e \in f\}$ |
| $\mathcal{Y}$ | set of edges with unassigned water flows; $\mathcal{Y} := \mathcal{E} \setminus \mathcal{X}$ |
| $d(e), e \in \mathcal{E}$ | integer indicating the minimum required diameter of the edge $e$ (in mm) |
| $d'(e), e \in \mathcal{E}$ | integer indicating the assigned diameter of the edge $e$; $d'(e) \in \mathcal{D}$ (in mm) |

Notation concerning the algorithms

**Algorithm 1** Diameter selection (DS) algorithm.

**Step 1:** Initialize the node $r$ and sets $\mathcal{C}$; $\mathcal{D}$; $m$; $\mathcal{E}(r, c), c \in C$; $\mathcal{X} := \varnothing$; $\mathcal{Y} := \mathcal{E}$.

**Step 2:** Choose at random an edge with unassigned water flow, i.e., an edge $e \in \mathcal{Y}$, set $w(e) := 0$, and update sets $\mathcal{X}$; $\mathcal{Y}$.

**Step 3:** For each water distribution consumption node $c \in C$:

(a) if $e \in \mathcal{E}(r, c)$, then set $w(e) := w(e) + w(c)$.

**Step 4:** If $w(e) > 0$, then:

(a) compute $d(e) := \sqrt{\frac{w(e)}{s \times \pi}} \times 2$, and set $d'(e) := \max(\mathcal{D})$.

(b) for each available pipe diameter $p \in \mathcal{D}$:

(i) if $p >= d(e)$ and $p < d'(e)$, then set $d'(e) := p$.

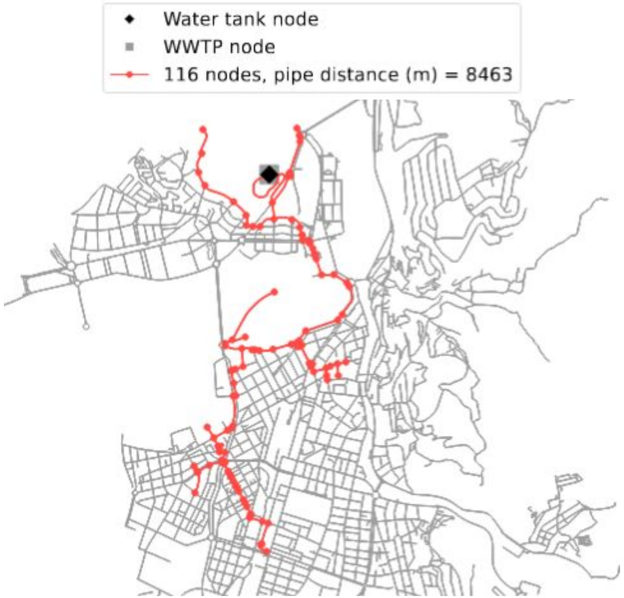
**Step 5:** If $\mathcal{Y} \neq \varnothing$, then go to Step 2.

**Step 6:** If $\mathcal{Y} = \varnothing$, then stop ($d'(e)$ contains the assigned pipe diameter $\forall e \in \mathcal{E}$).

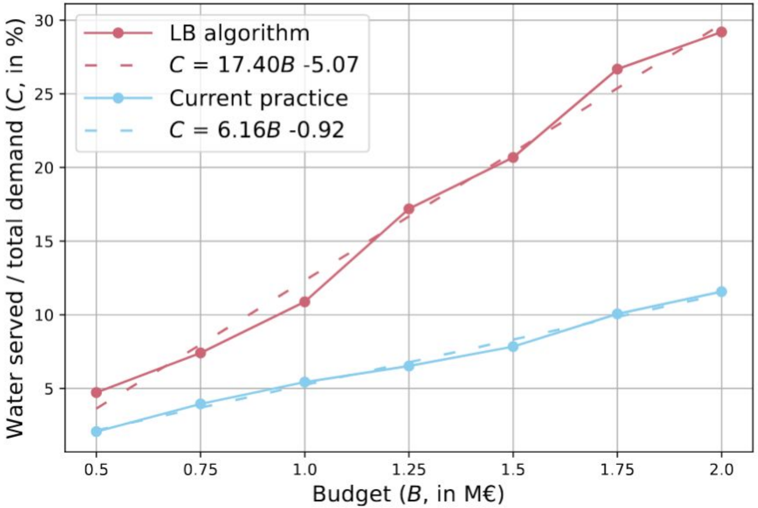
*Optimal design of water reuse networks in cities.*
*submitted to npj Clean Water*

# Algorithms (reclaimed water)

- Limited Budget availability (LB) algorithm: Maximizes the water volume served.
  - Serves almost **three times** more water compared to current practice.




Optimized network for Girona (1M€)

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Notation concerning the algorithms

**Algorithm 2** Limited Budget availability (LB) algorithm.

**Step 1:** Initialize the node $r$, the budget $B$, and sets $\mathcal{C}$; $\mathcal{D}$; $m$.

**Step 2:** Let $\mathcal{T}$ be the initial graph with $\mathcal{V}' := \{r\}$ and $\mathcal{E}' := \varnothing$.

**Step 3:** Set the profit $P := 0$, the iteration candidate node $n := \varnothing$, and its current network's closest node $o := \varnothing$.

**Step 4:** For each reclaimed water consumption node $c : c \in \mathcal{C}, c \notin \mathcal{V}'$:

(a) Get the node $a \in \mathcal{V}'$ that minimizes the path to join $\mathcal{T}$ with $c$, such that:

$$\sum l(e), e \in \mathcal{E}(a,c) := \min((\sum l(e), e \in \mathcal{E}(v',c)), v' \in \mathcal{V}')$$

(b) Copy the graph $\mathcal{T}$ to $\mathcal{U}$, such that $(\mathcal{V}'', \mathcal{E}'') := (\mathcal{V}', \mathcal{E}')$.

(c) Add the $(a,c)$ path to graph $\mathcal{U}$, such that $\mathcal{V}'' := \mathcal{V}'' \bigcup \{a\}$, and $\mathcal{E}'' := \mathcal{E}'' \bigcup \mathcal{E}(a,c)$.

(d) Compute Algorithm 1 (DS) with $\mathcal{U}$ and $\mathcal{D}$, to obtain the pipe diameters $d'(e), e \in \mathcal{E}''$.

(e) Calculate the pipe network construction cost $Z$ of $\mathcal{U}$ (including the initial water tank) from $d'(e)$ and $l(e)$, $e \in \mathcal{E}''$ (see Supplementary Tables 1 and 3).

(f) If $Z <= B$, then:

(i) Compute the profit $P'$ of adding $a$ to $\mathcal{T}$, such that $P' := \frac{m(a)^3}{L}$, where $L := \sum l(e), e \in \mathcal{E}(a,c)$.

(ii) If $P' > P$, then set $P := P'$, $n := a$, and $o := c$.

**Step 5:** If $P > 0$, then:

(a) Add the $(n,o)$ path to graph $\mathcal{T}$, such that $\mathcal{V}' := \mathcal{V}' \bigcup \{o\}$, and $\mathcal{E}' := \mathcal{E}' \bigcup \mathcal{E}(n,o)$.

(b) Go to Step 3.

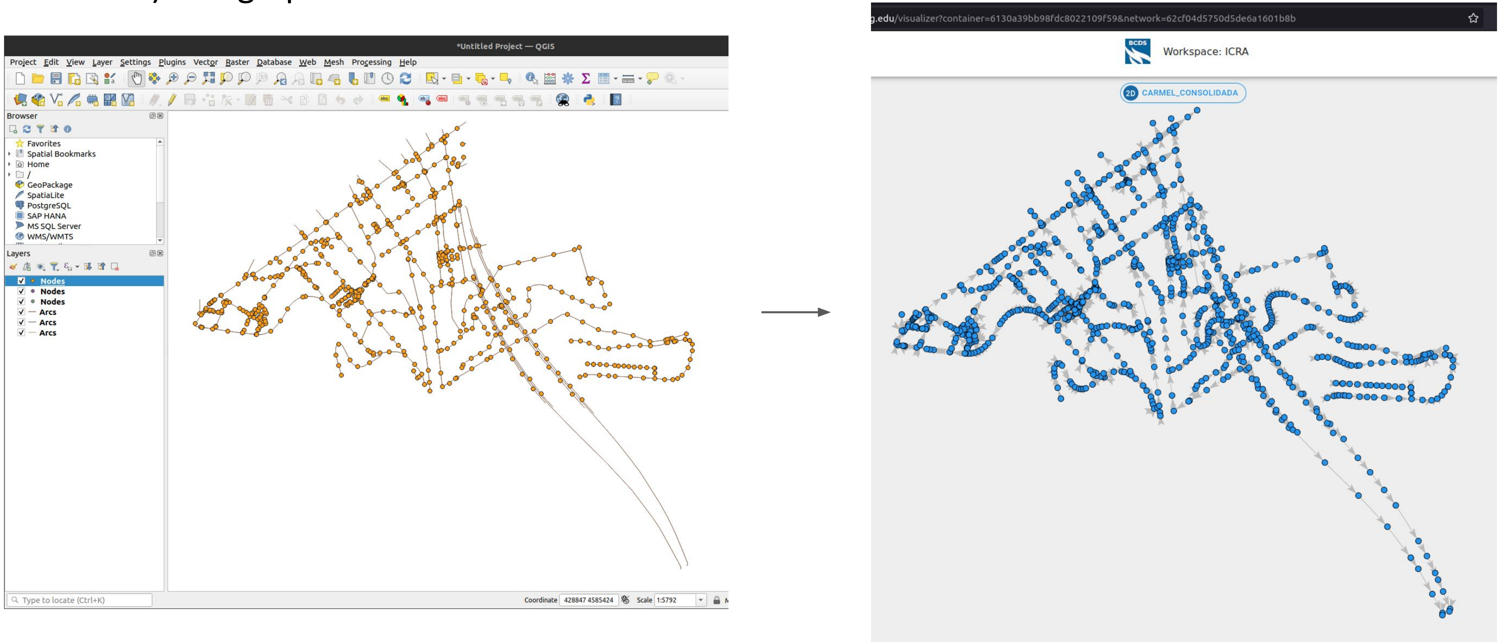
**Step 6:** $\mathcal{T}$ represents the final reclaimed network graph $\mathcal{G}$.

*Optimal design of water reuse networks in cities.*
*submitted to npj Clean Water*

# Water network modeling (wastewater)



- What if we want to work with real-world wastewater networks?
- Semi-automatic framework to convert QGIS and shapefile projects (normally owned by water/public authorities) to a graph.

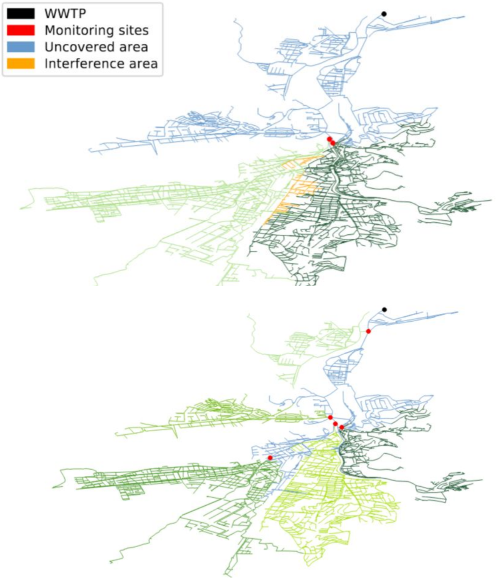



Network modeling module (Wastewater network)

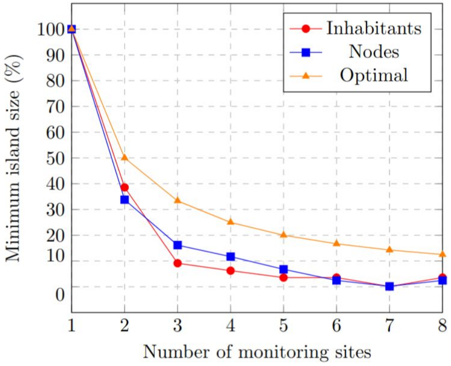
# Sensor placement module (wastewater)

- Monitoring is really important for both drinking water and wastewater networks.
- **Water quality:** Contaminants, viruses… **Water availability:** DoS attacks, failures…

- Example: Locate monitoring sites to detect Sars-CoV-2 (similar coverage areas with no interference).




Monitoring sites for Sars-CoV-2 detection




*Calle, E., Martínez, D., Brugués-i-Pujolràs, R., Farreras, M., Saló-Grau, J., Pueyo-Ros, J., & Corominas, L. (2021). Optimal selection of monitoring sites in cities for SARS-CoV-2 surveillance in sewage networks. Environment International, 157, 106768.*

# Blockchain IoT Water module

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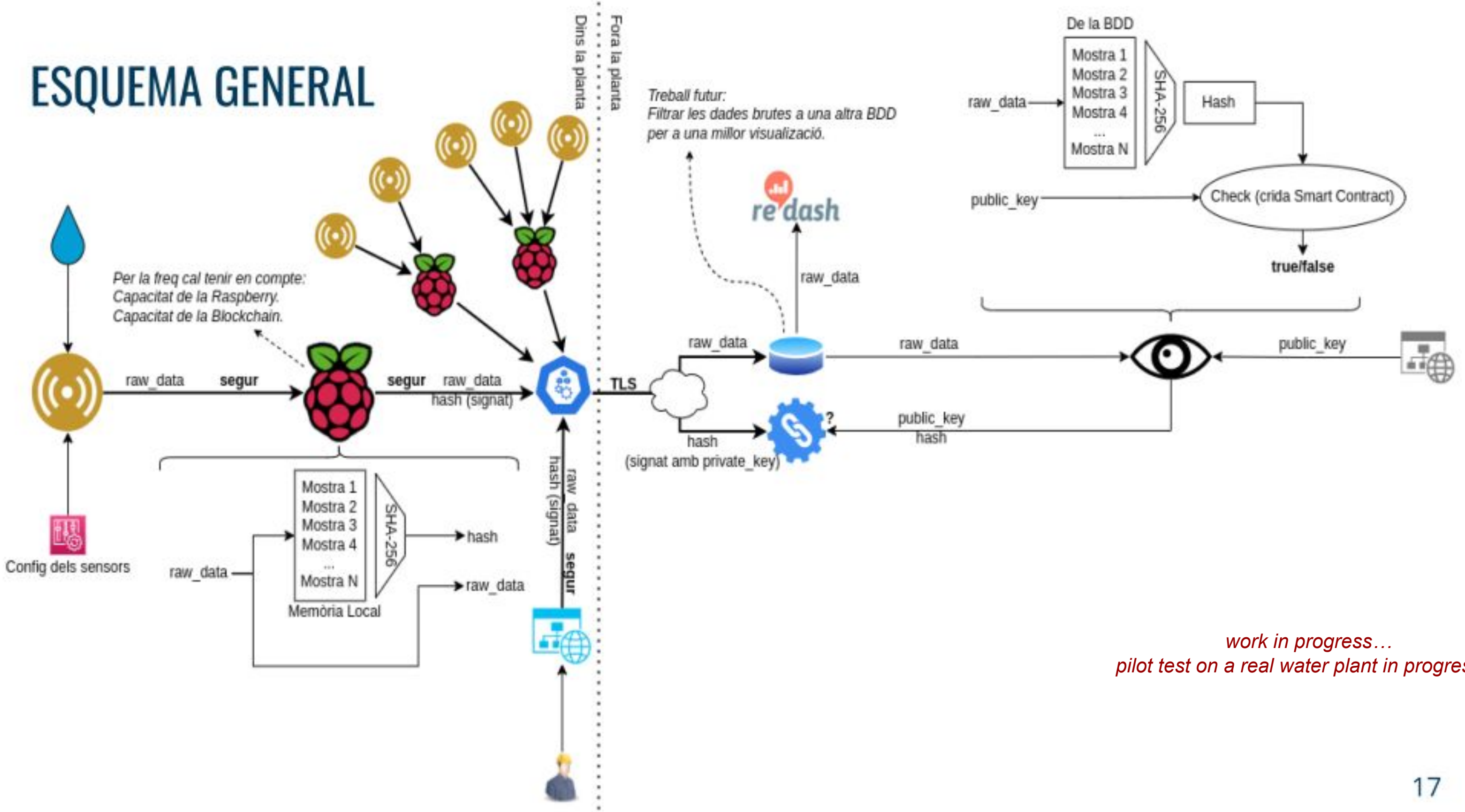
- Use of blockchain techniques to validate data from sensors on water networks.




*work in progress…*
*pilot test on a real water plant in progress…*

# What about user privacy?

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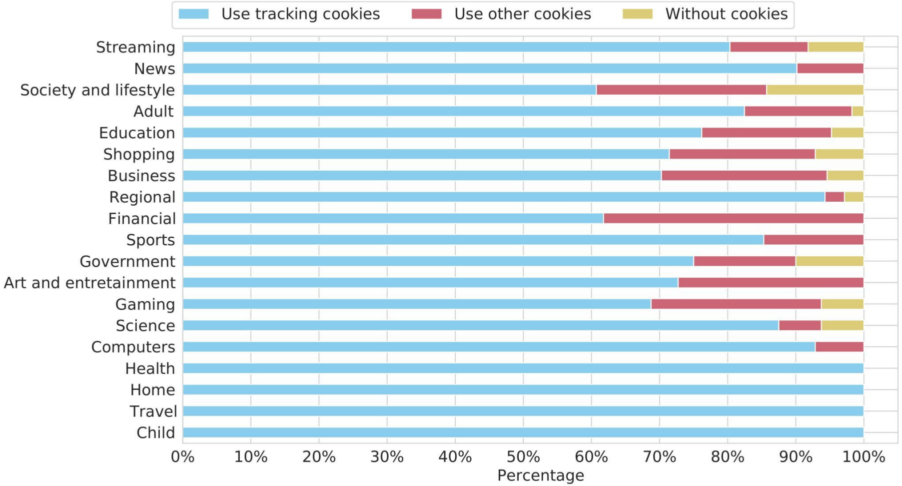
- Not in our research areas, although we recently published a paper.
- Are we aware of the influence of web-tracking technologies?
- Our latest research findings are stunning: More than three-quarters of our analyzed website sample use tracking cookies or similar techniques without user consent. Although most websites ask for user consent, it is usually not respected in practice. The consent collection confidence that websites provide is almost non-existent.




***Number of websites that use cookies without user consent aggregated by categories***

*Martínez, D., Calle, E., Jové, A., & Pérez-Solà, C. (2022). Web-tracking compliance: websites' level of confidence in the use of information-gathering technologies. Computers & Security, 122, 102873.*

# Conclusions

- **Current research areas:** Network optimization (water network algorithms). Network security on SDN and applied sciences (BCPP, sensor placement, blockchain…).
- Looking for a research line for PhD thesis based on or improving previous work: networks, security, water, etc.
- Looking forward to collaborating! :)
- Questions?

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