RadioWeaves for Communication, Positioning, and WPT: How to Share Resources?

@ 2022 Asilomar Conference on Signals, Systems, and Computers

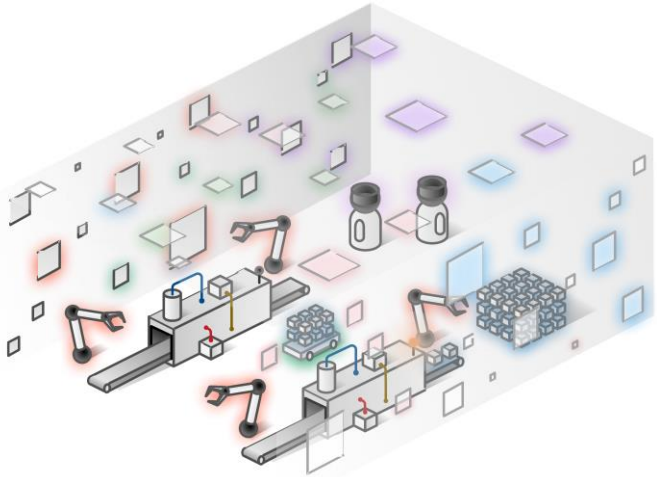
Authors: Gilles Callebaut, Emma Fitzgerald, Liang Liu, Lieven De Strycker, Fredrik Tufvesson, Liesbet Van der Perre

Presented by Gilles Callebaut
Ghent Technology Campus, B-9000 Ghent, Belgium
gilles.callebaut@kuleuven.be

The project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101013425.

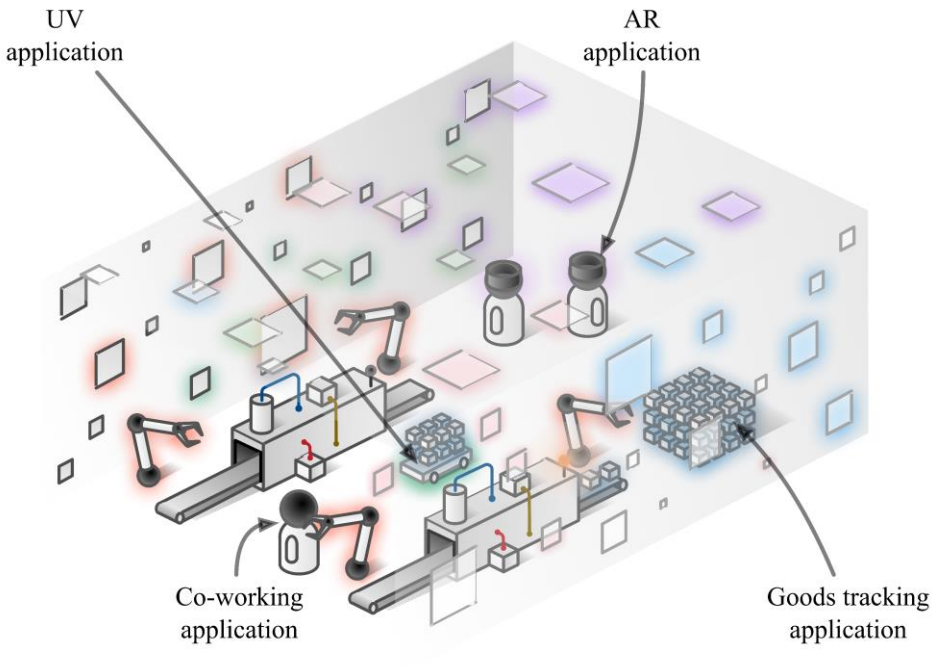
From Co-Located to RadioWeaves (RW) Infrastructures

https://mediabank.ericsson.net/portfolio/main/139254_cb111f535f54887a0e818be814225dea.jpg



Callebaut, G., **Tärneberg, W.**, Van der Perre, L., & Fitzgerald, E. (2022). Dynamic Federations for 6G Cell-Free Networking: Concepts and Terminology. *IEEE SPAWC 2022*.

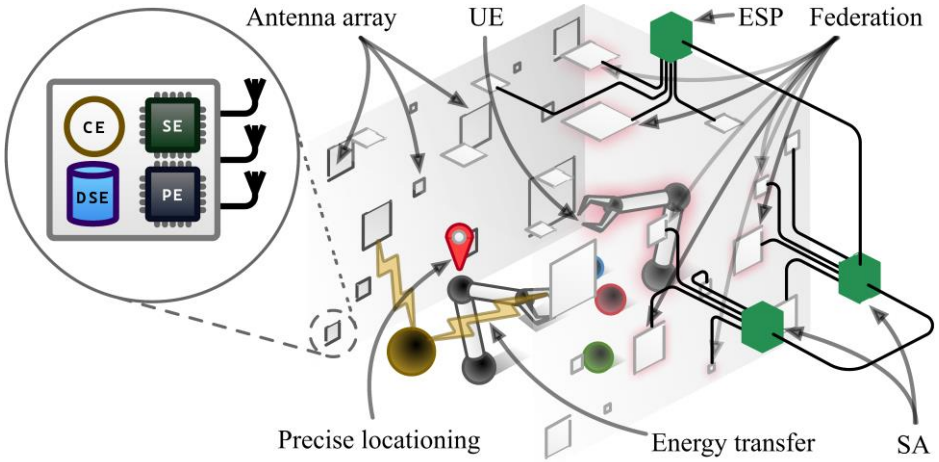
Abundance of resources to serve a myriad of applications



G. Callebaut et al., "Techtile – Open 6G R&D Testbed for Communication, Positioning, Sensing, WPT and Federated Learning," 2022 Joint European Conference on Networks and Communications & 6G Summit (EuCNC/6G Summit), 2022, pp. 417-422, doi: 10.1109/EuCNC/6GSummit54941.2022.9815696.

RadioWeaves for Communication, Positioning, and WPT: How to Share Resources?

Under the hood – New terminology

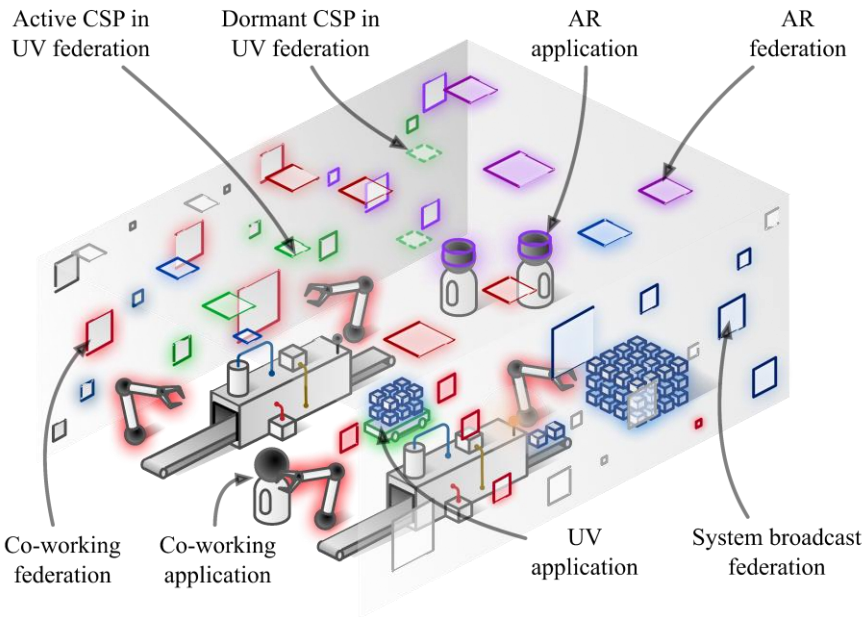


Callebaut, G., Tärneberg, W., Van der Perre, L., & Fitzgerald, E. (2022). Dynamic Federations for 6G Cell-Free Networking: Concepts and Terminology. *IEEE SPAWC 2022*.

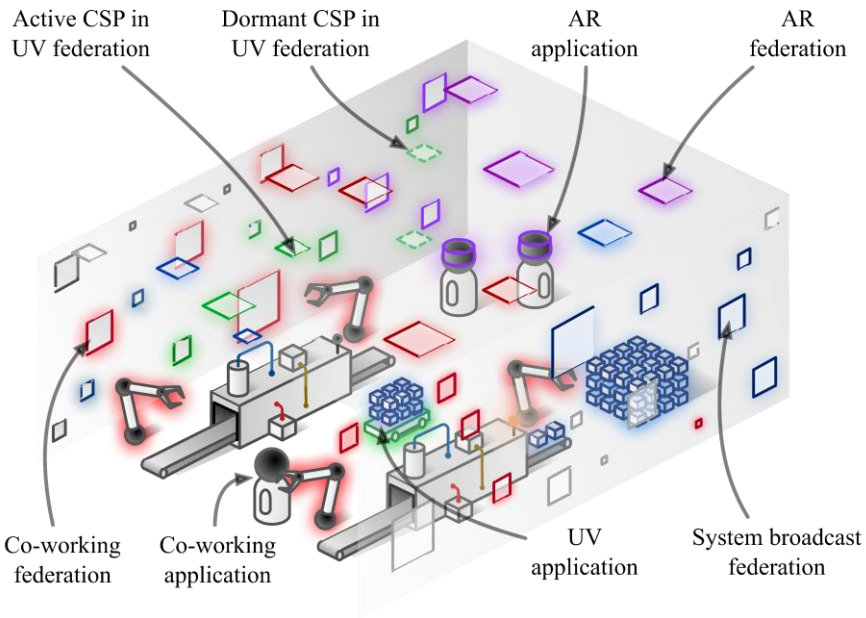
General challenges of RadioWeaves (concept)

- Distinct application requirements
- Fairness among applications
- Energy optimization of the network
- Synchronisation and cooperation between resources
- Scalability versus cost
- Very heterogeneous system

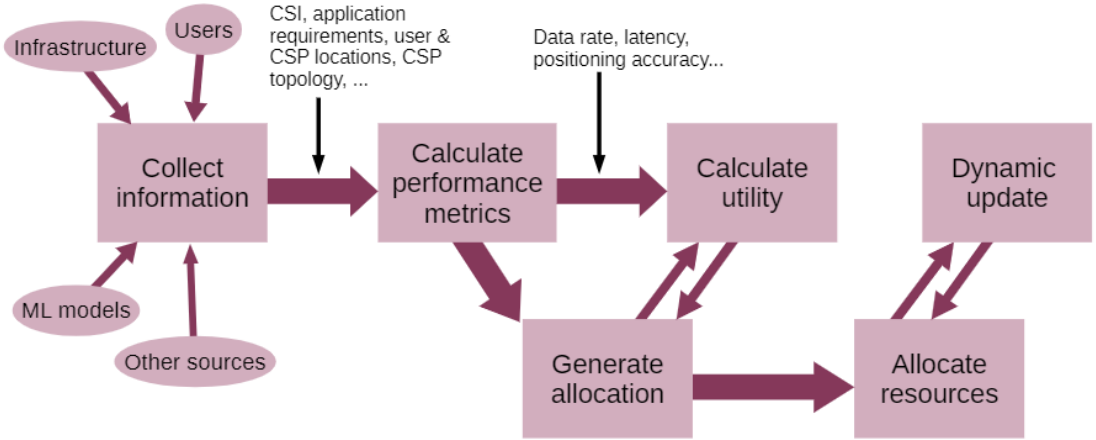
Federation orchestration challenges



Why federations?



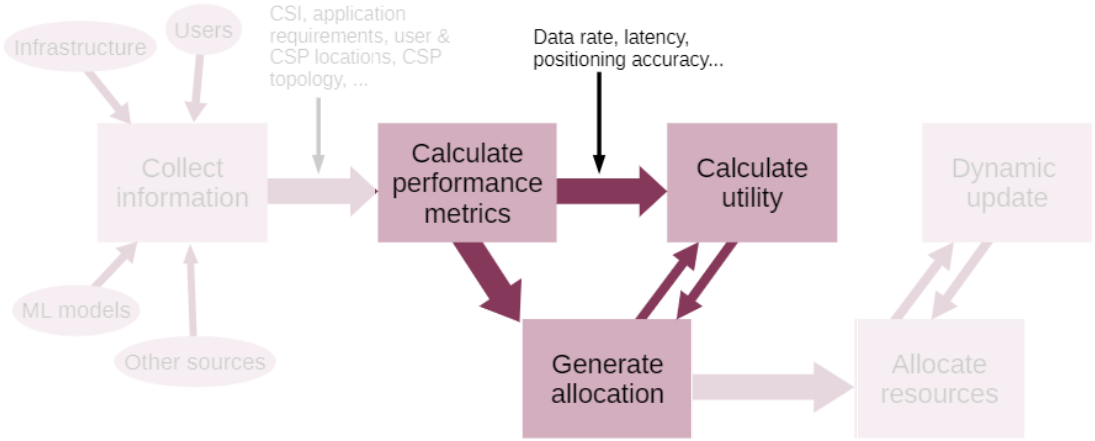
Our tools



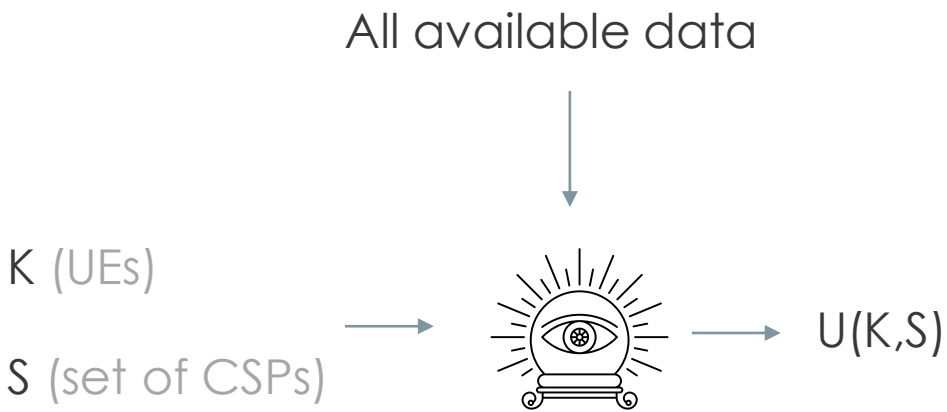
https://github.com/ToonKeymeulen/Simulator_FO

Keymeulen, Toon. "High-Level Simulator of Federation Orchestration." (2022).

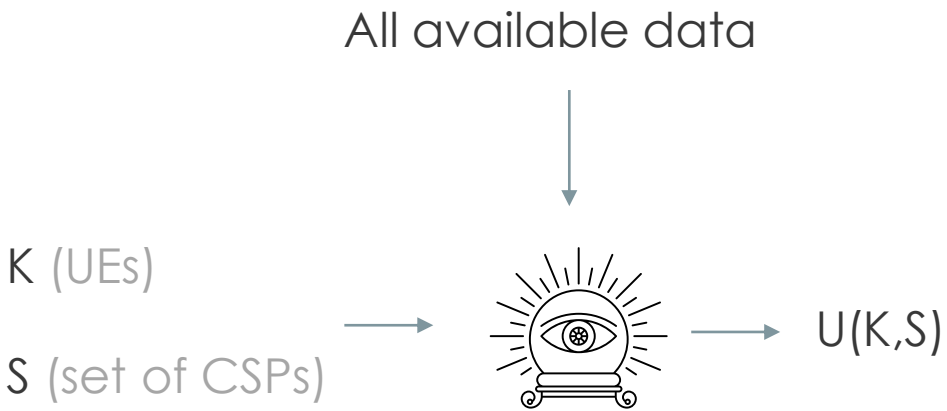
Utility and allocation



Utility and allocation – The Oracle



Utility and allocation – The Oracle



- How to group users?
- How to allocate CSPs to federations?
- How to define a utility of a federation?

The Oracle – UE utility

Set of Performance metric for k

User k

Min. required value

$$U(\{k\}, \mathcal{S}_{f(k)}) = \max(\min_{i \in \mathcal{P}_k}(p_k^i - P_k^i), 0)$$

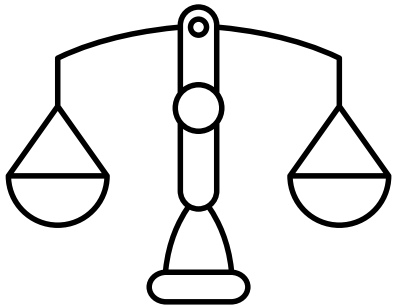
Set of CSPs assigned to federation f

Value of performance

The Oracle – Federation Utilities

Fairness

e.g., minimum



Utility

e.g., sum or average

Federation Resource allocation problem

$$
\begin{aligned}
\max \quad & U(\mathcal{F}) \\
& (1 - z_f) + U(\mathcal{K}(f), \mathcal{S}(f)) > 0, && f \in \mathcal{F} && (1) \\
& \frac{1}{|\mathcal{K}|} \sum_{k \in \mathcal{K}} x_k^f \leq z_f, && f \in \mathcal{F} && (2) \\
& z_f \leq x_k^f, && k \in \mathcal{K},\ f \in \mathcal{F} && (3) \\
& \sum_{f \in \mathcal{F}} x_k^f = 1, && k \in \mathcal{K} && (4) \\
& \sum_{f \in \mathcal{F}} y_s^f \leq 1, && s \in \mathcal{S} && (5) \\
& x_k^f \in \{0, 1\}, && k \in \mathcal{K},\ f \in \mathcal{F} \\
& y_s^f \in \{0, 1\}, && s \in \mathcal{S},\ f \in \mathcal{F} \\
& z_f \in \{0, 1\}, && f \in \mathcal{F}
\end{aligned}
$$

$\mathcal{F}$ Set of federations

$\mathcal{K}$ Set of UEs

x_k^f UE k in f

y_s^f CSP s in f

z_f f used

UE Grouping

- Based on their use case / application
- Through self-reported utilities (based on potential CSP allocations)
  1. Generate a set of sample CSP constellations
  2. Utility of each UE (per CSP constellation)
  3. Cluster UEs based on their utility
  4. Optional: divide large clusters in multiple clusters

Initial Results

- WPT

$$r_{k,l} = \sqrt{P_{k,l}} w_{k,l} s_k h_{k,l} + n_{k,l} + \sum_{k' \neq k}^{K} \sqrt{P_{k',l}} w_{k',l} s_{k'} h_{k,l} \qquad r_k = \sum^{L} r_{k,l}$$

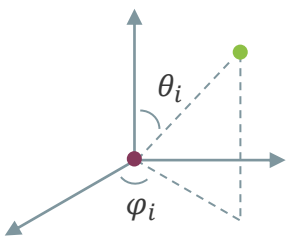
$\sqrt{\beta_{k,l}} CN(0,1)$

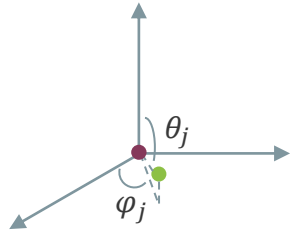
- Positioning

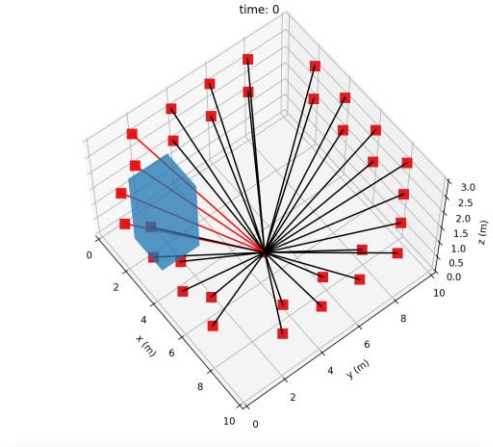
Keymeulen, Toon. "High-Level Simulator of Federation Orchestration." (2022).

Initial Results

- WPT



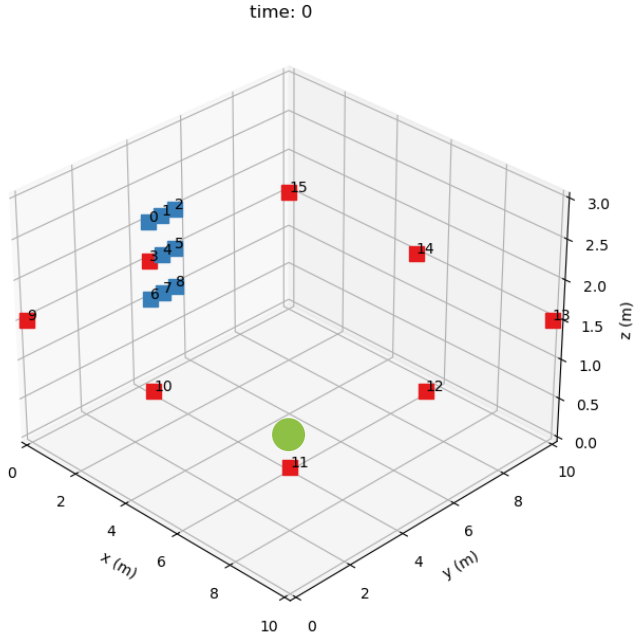


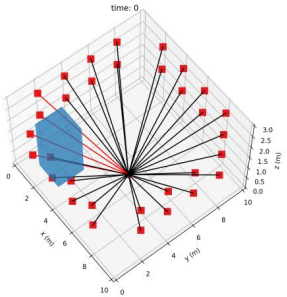


- Positioning
  - $U_{UE} = \max\left(\frac{1}{180}|\theta_i - \theta_j|, \frac{1}{360}|\phi_i - \phi_j|\right)$

Initial Results

- WPT
- Positioning

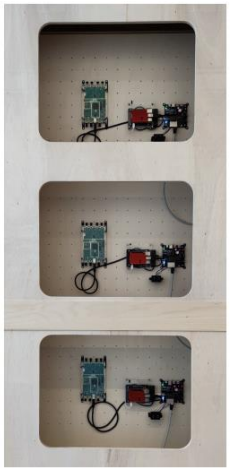




Keymeulen, Toon. "High-Level Simulator of Federation Orchestration." (2022).

Ongoing and future work

- Implement different algorithms for CSP allocation to the federations
- Improve Oracle with more detailed utility functions
- Include RadioWeave-specific channel conditions
- Implement it in the Techtile testbed



G. Callebaut et al., "Techtile – Open 6G R&D Testbed for Communication, Positioning, Sensing, WPT and Federated Learning," 2022 Joint European Conference on Networks and Communications & 6G Summit (EuCNC/6G Summit), 2022, pp. 417-422, doi: 10.1109/EuCNC/6GSummit54941.2022.9815696.

RadioWeaves for Communication, Positioning, and WPT: How to Share Resources?

@ 2022 Asilomar Conference on Signals, Systems, and Computers

Authors: Gilles Callebaut, Emma Fitzgerald, Liang Liu, Lieven De Strycker, Fredrik Tufvesson, Liesbet Van der Perre

Presented by Gilles Callebaut
Ghent Technology Campus, B-9000 Ghent, Belgium
gilles.callebaut@kuleuven.be

The project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101013425.