

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

@ 2022 Asilomar Conference on Signals, Systems, and Computers

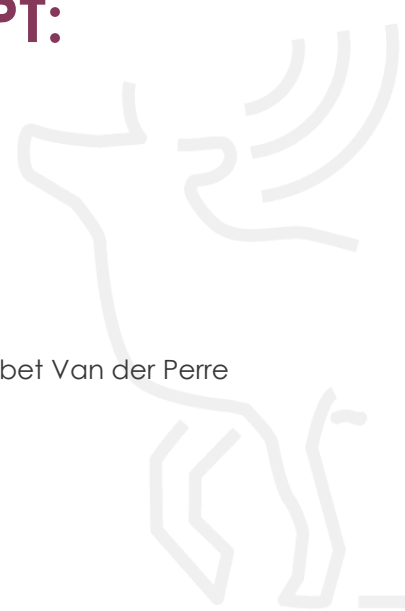
Authors: Gilles Callebaut, Emma Fitzgerald, Liang Liu, Lieven De Strycker, Fredrik Tufvesson, Liesbet Van der Perre

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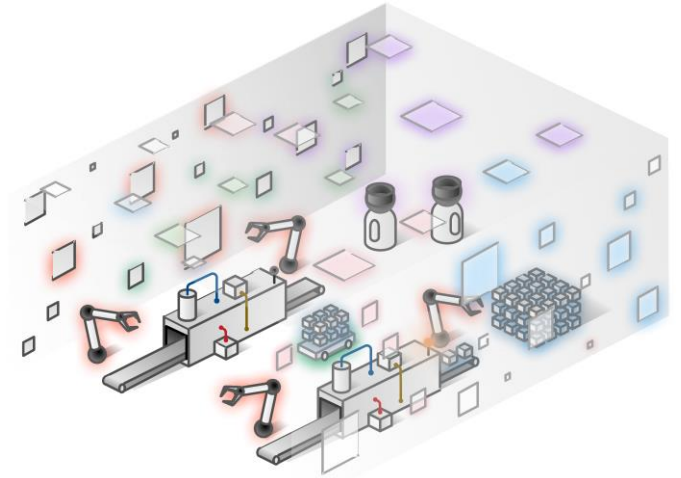


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The project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101013425.



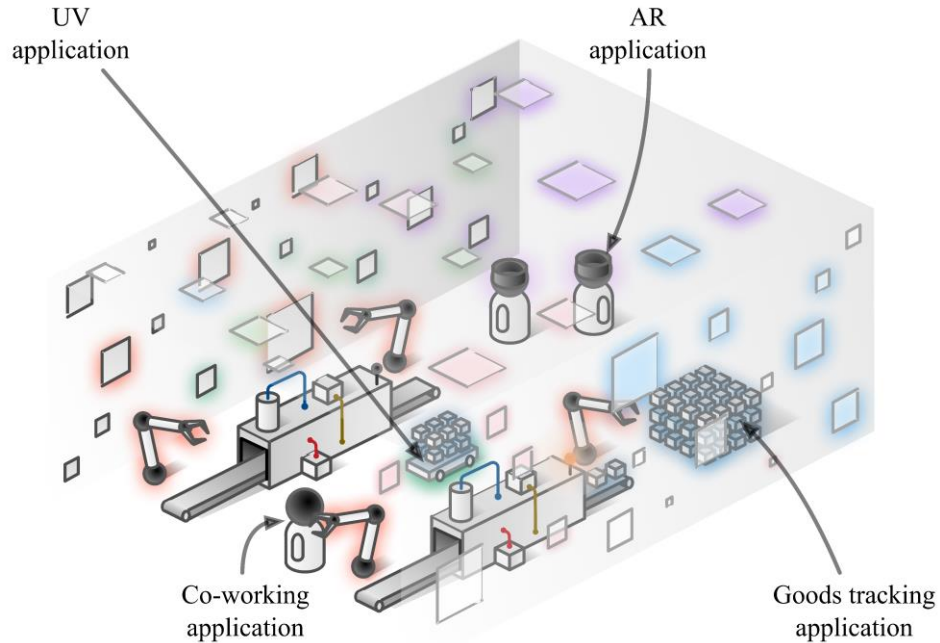
From Co-Located to RadioWeaves (RW) Infrastructures



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

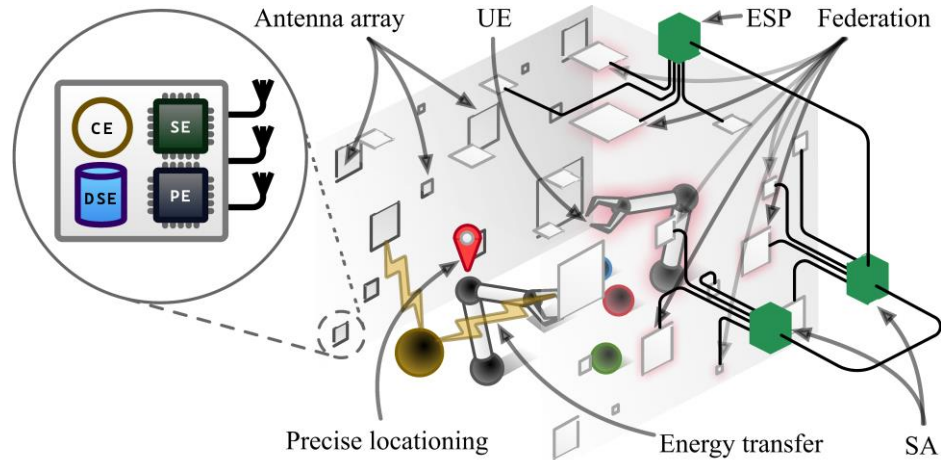


G. Callebaut et al., "Techtile - Open 6G R&D Testbed for Communication, Positioning, Sensing, WPT and Federated Learning," 2022 Joint European Conference on Networks and Communications & 6G Summit (EuCNC/6G Summit), 2022, pp. 417-422, doi: 10.1109/EuCNC/6GSummit54941.2022.9815696.

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



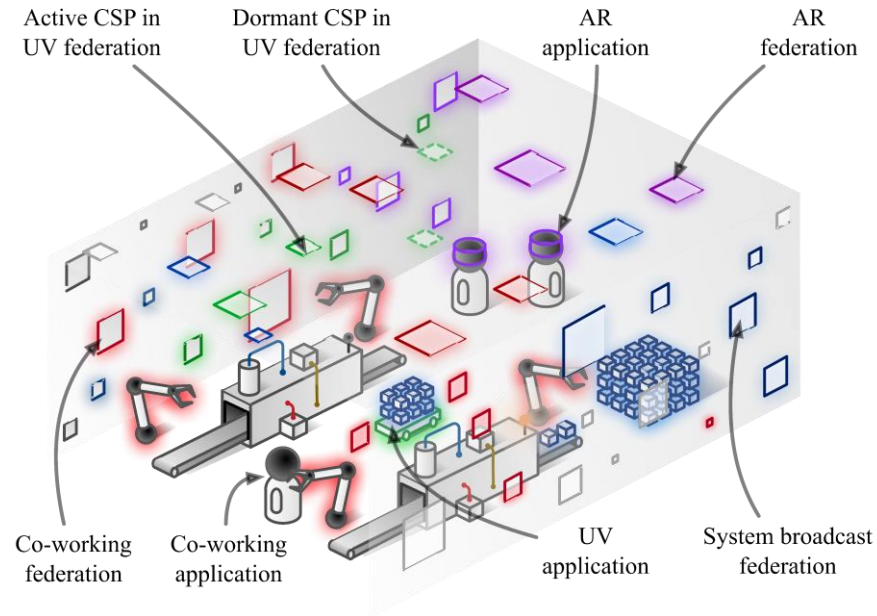
Under the hood – New terminology



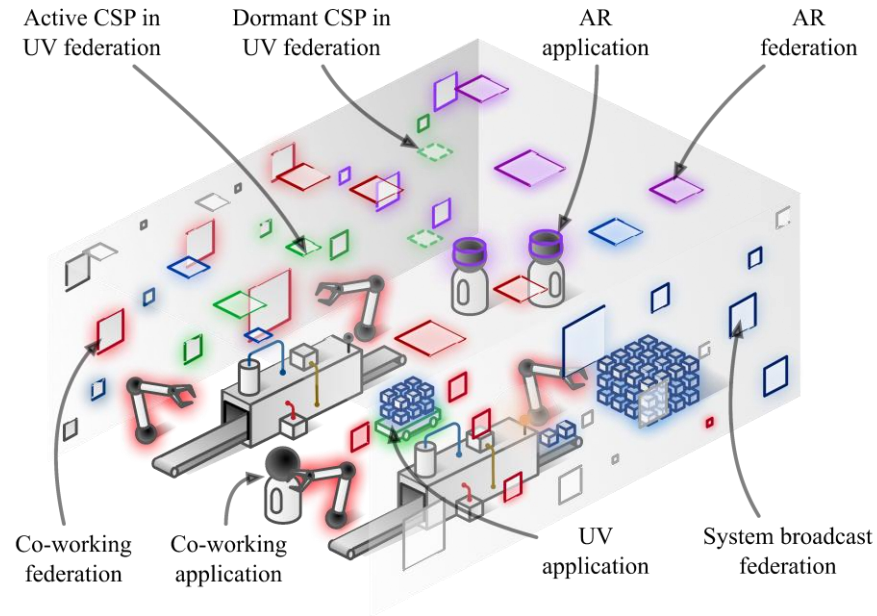
General challenges of RadioWeaves (concept)

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

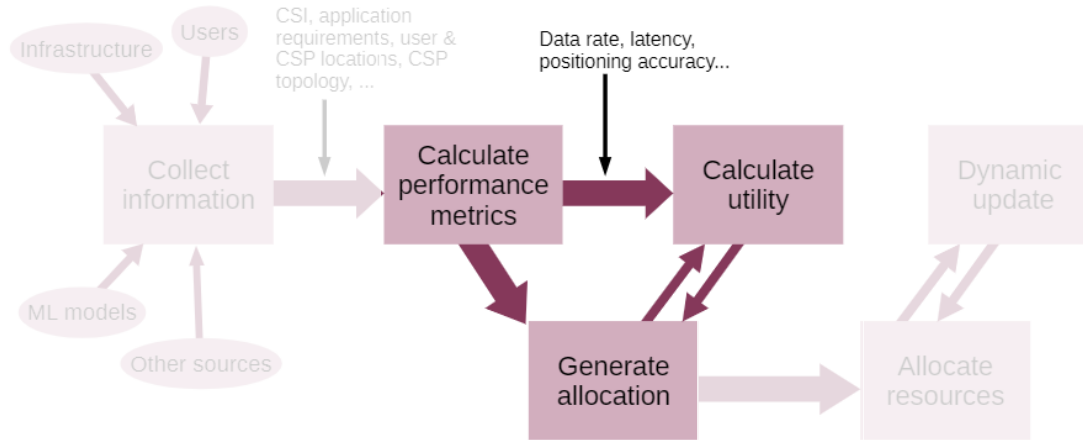
Federation orchestration challenges



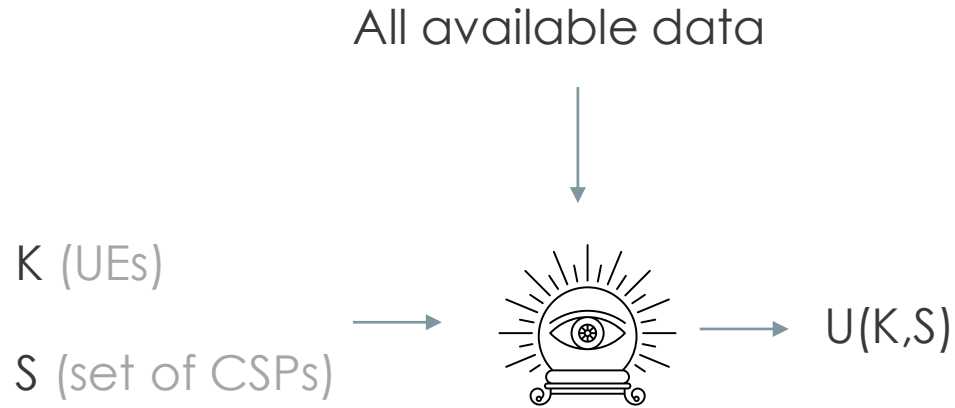
Why federations?



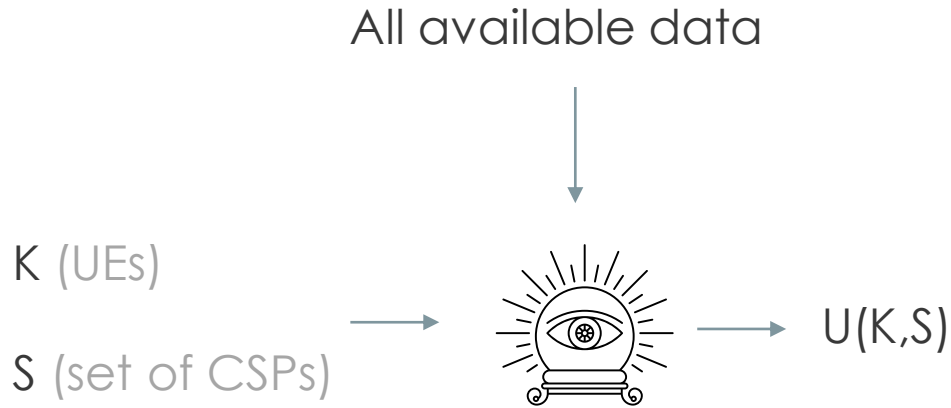
Utility and allocation



Utility and allocation – The Oracle

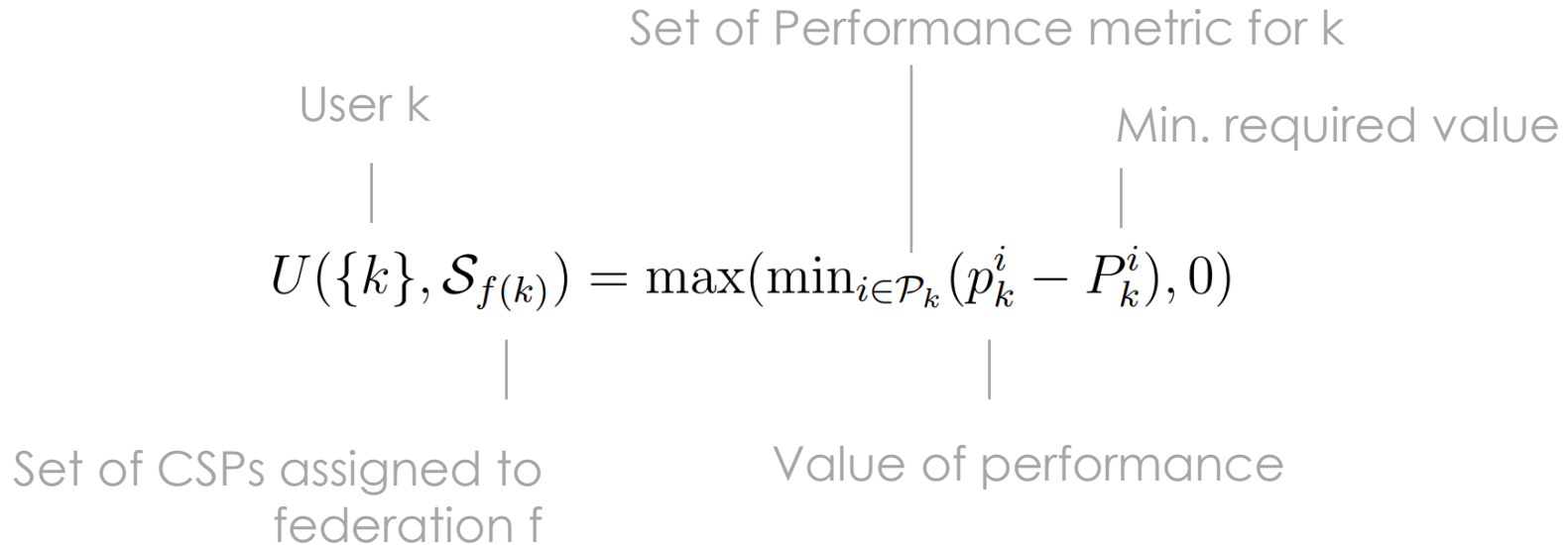


Utility and allocation – The Oracle



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

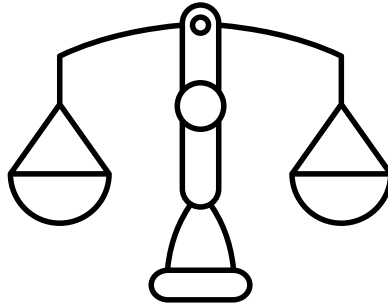
The Oracle – UE utility



The Oracle – Federation Utilities



Fairness
e.g., minimum



Utility
e.g., sum or average

Federation Resource allocation problem

$$\max U(\mathcal{F})$$

$$(1 - z_f) + U(\mathcal{K}(f), \mathcal{S}(f)) > 0,$$

$$\frac{1}{|\mathcal{K}|} \sum_{k \in \mathcal{K}} x_k^f \leq z_f,$$

$$z_f \leq x_k^f,$$

$$\sum_{f \in \mathcal{F}} x_k^f = 1,$$

$$\sum_{f \in \mathcal{F}} y_s^f \leq 1,$$

$$x_k^f \in \{0, 1\},$$

$$y_s^f \in \{0, 1\},$$

$$z_f \in \{0, 1\},$$

$$f \in \mathcal{F} \quad (1)$$

$$f \in \mathcal{F} \quad (2)$$

$$k \in \mathcal{K}, f \in \mathcal{F} \quad (3)$$

$$k \in \mathcal{K} \quad (4)$$

$$s \in \mathcal{S} \quad (5)$$

$$k \in \mathcal{K}, f \in \mathcal{F}$$

$$s \in \mathcal{S}, f \in \mathcal{F}$$

$$f \in \mathcal{F}$$

\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

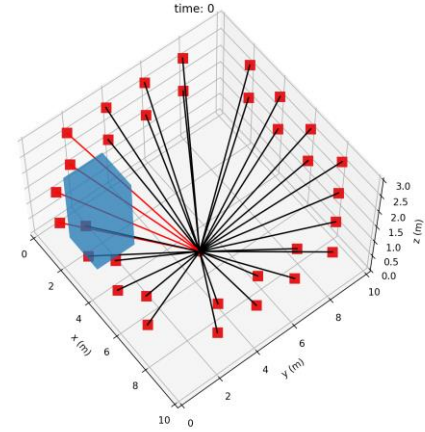
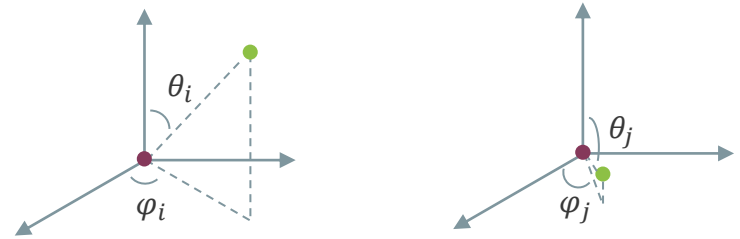
- WPT

$$r_{k,l} = \sqrt{P_{k,l}} w_{k,l} s_k h_{k,l} + n_{k,l} + \sum_{k' \neq k} \sqrt{P_{k',l}} w_{k',l} s_{k'} h_{k,l} \quad r_k = \sum_l r_{k,l}$$

- Positioning

Initial Results

- WPT

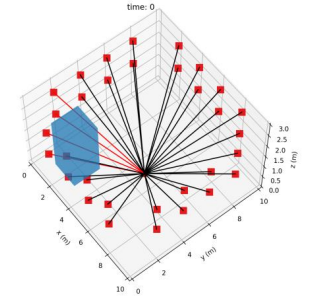


- Positioning

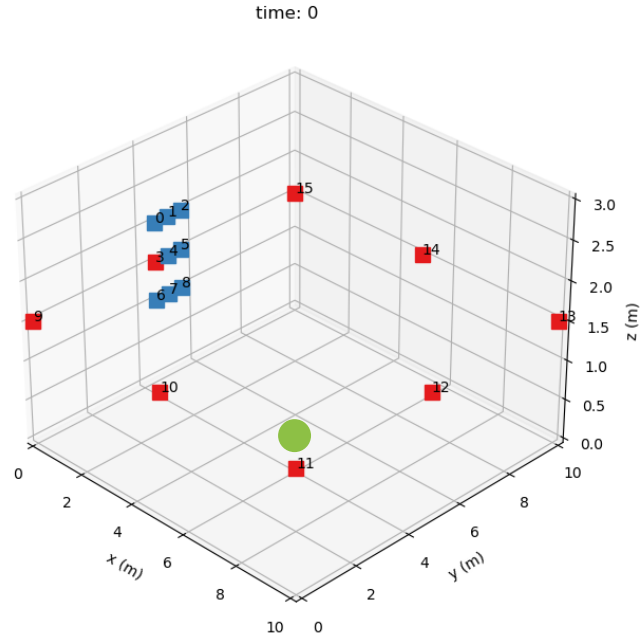
- $U_{UE} = \max\left(\frac{1}{180}|\theta_i - \theta_j|, \frac{1}{360}|\phi_i - \phi_j|\right)$

Initial Results

- WPT ■

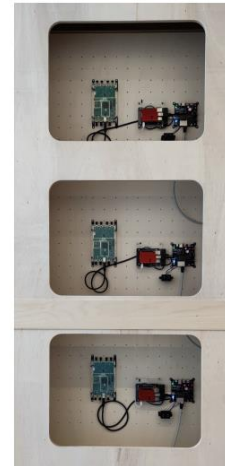


- Positioning ■



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



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