Our activities in Wireless optimization

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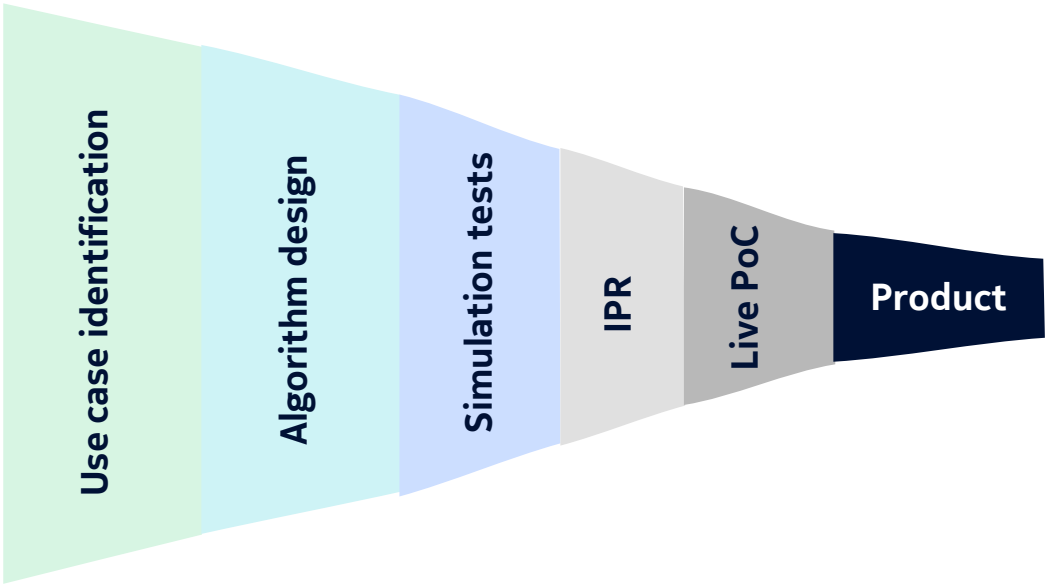
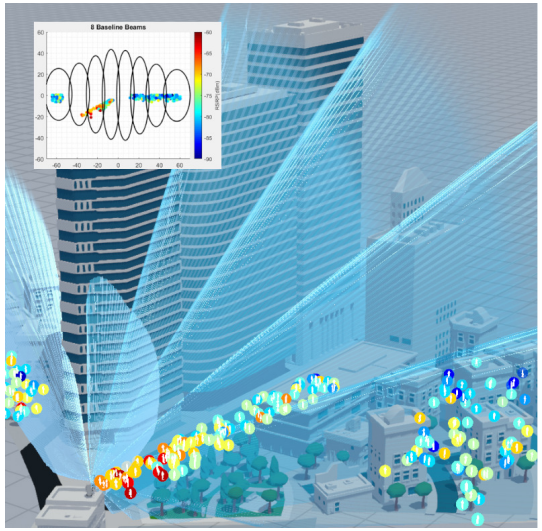
Way of Working



Grid of Beams optimization

Combinatorial (submodular) optimization



- Beam patterns do not reflect user distribution
- Waste of resources
- Sub-optimal signal strength at user positions

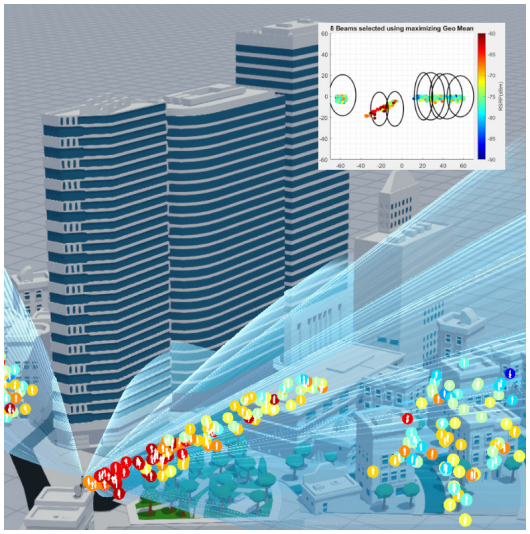
Maximize fairness across UEs

$$\max_{\mathcal{B}\subset\mathcal{D}:|\mathcal{B}|=N} J(\mathcal{B}).$$

$$J(\mathcal{B}) = \sum_u \rho(u) f^{(\omega)}\left(G_{\mathcal{B}}^{\text{top}-K}(u)\right)$$

$$f^{(\omega)}(x) = \begin{cases} x^{1-\omega}/(1-\omega) & \text{if } \omega \geq 0,\ \omega \neq 1 \\ \log(x) & \text{if } \omega = 1 \end{cases}$$

$$G_{\mathcal{B}}^{\text{top}-K}(u) := \sum_{i=1}^{K} G(u, b_i^{\mathcal{B}}(u))$$



- Beam patterns reflect user distribution
- No waste of resources
- Optimal signal strength at user positions
- Handling Coverage gaps
- Intercell interference in multi-cell optimization

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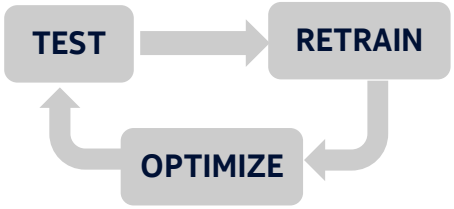
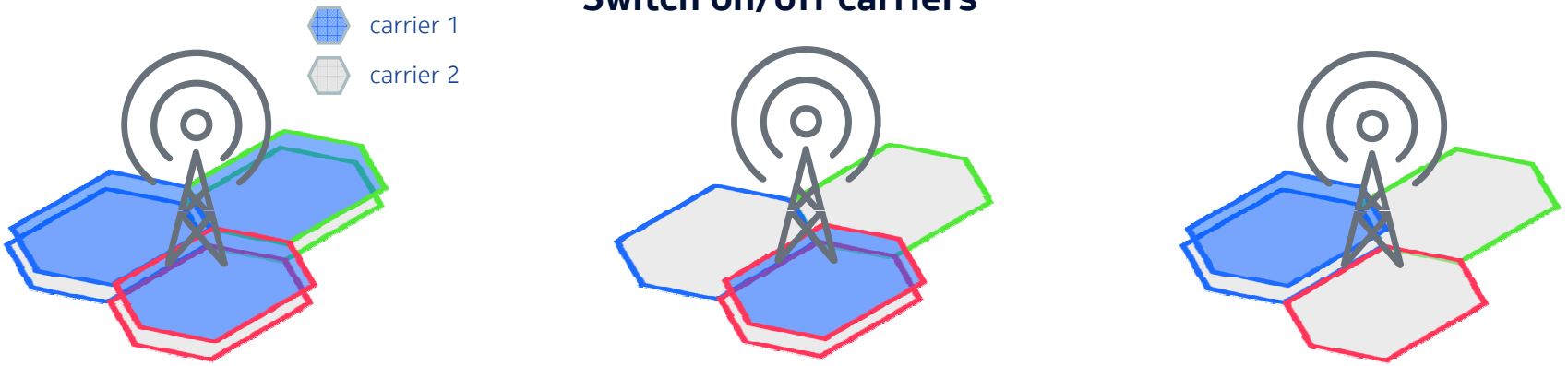
Energy savings at the base station

Bayesian parametric optimization



Switch on/off carriers



$$\min_{A_t \subset \mathcal{C}} \lim_{T\to\infty} \frac{1}{T+1} \sum_{t=0}^{T} \mathbb{E}\left[w_t(\mathcal{A}_t)\right]$$

Minimize energy consumption at base station

$$\text{s.t.} \lim_{T\to\infty} \frac{1}{\sum_{t=0}^{T} |\mathcal{A}'_t|} \sum_{t=0}^{T} \sum_{c\in\mathcal{A}'_t} \mathbb{E}\left[f\left(\{\mathrm{KPI}_t^{i,c}\}_{i=1}^{K}\right)\right] \geq \xi.$$

while not degrading QoS with high probability

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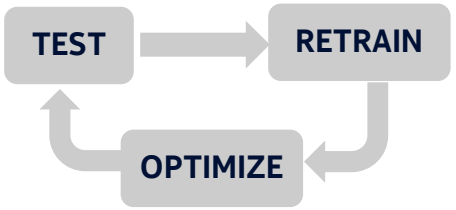
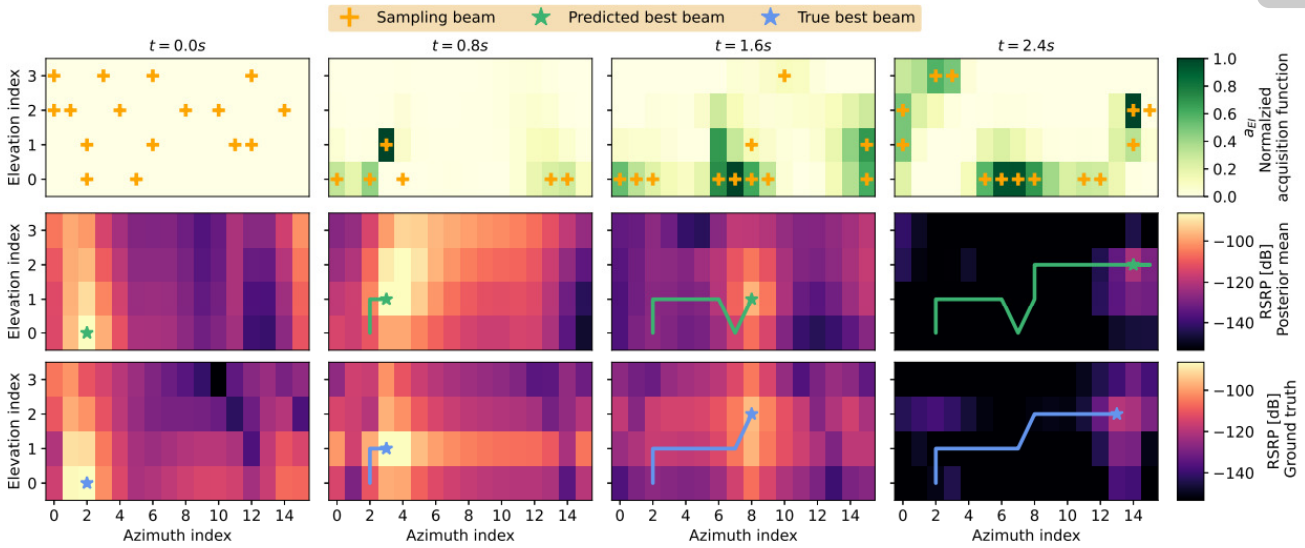
Beam tracking

Non-parametric Bayesian optimization





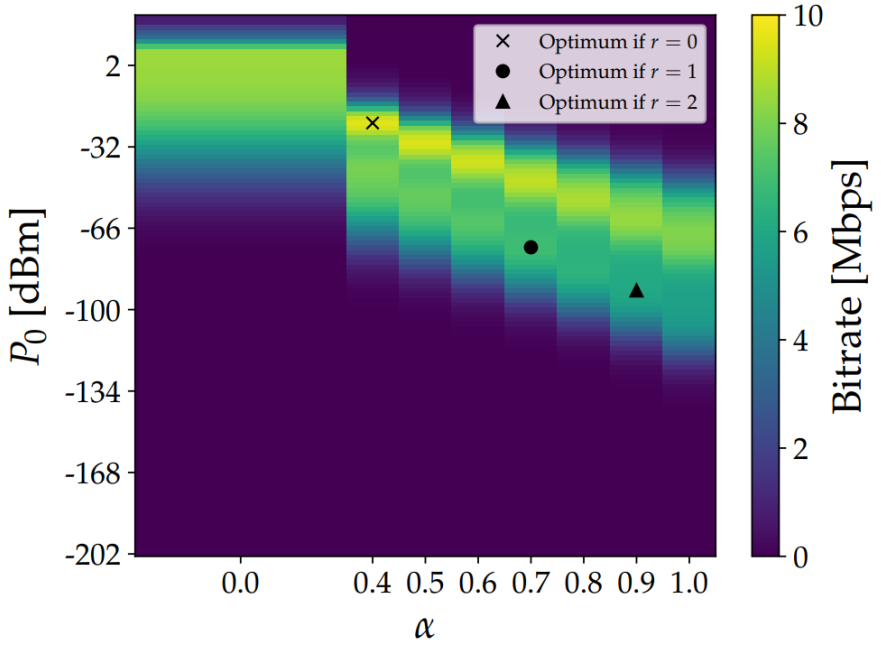
$$B_t = \underset{B \subset \Gamma_{\mathrm{BS}}}{\arg\max}\, \mathbb{E}\left[f_t(B) - f_t^*\right]^+ - h(|B|),$$

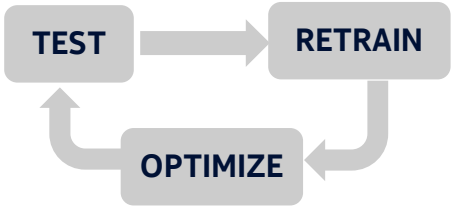
Maximize RX power over time while limiting the number of beams

Uplink power control

Non-parametric Bayesian optimization

$$P_{PUSCH} = \min\{P_{CMAX},\ P_0 + 10\log(M_{RB}) + \alpha PL + CL\}$$





Maximize thpt fairness across UEs

Maximize expected improvement

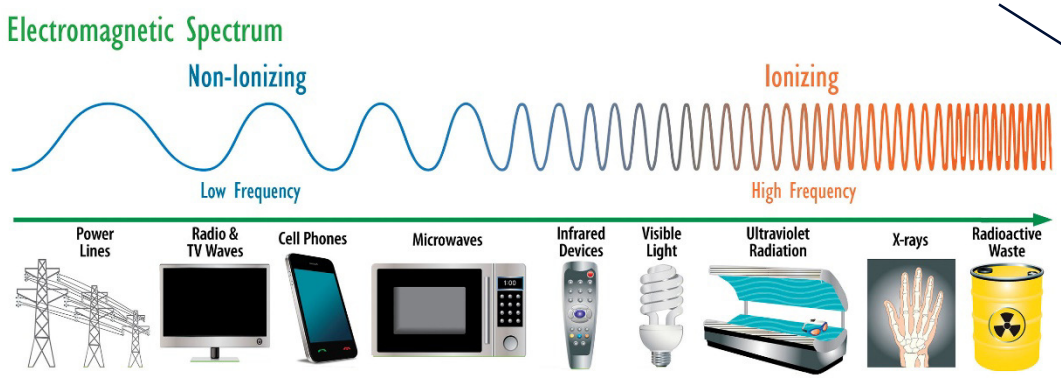
$$\textbf{max}\ u^{\mathrm{EI}}(\boldsymbol{x}|\mathbf{o}(n)) = \mathbb{E}\left[f(\boldsymbol{x}) - \max_{i=1,\ldots,n} f(\boldsymbol{x}(i)) \,\middle|\, \mathbf{o}(n)\right]^{+}.$$

Radiation exposure mitigation

Lyapunov optimization

ensure EMF radiation (avg over sliding window) is low enough

Maximize traffic performance



$$\max_{\gamma} \lim_{T\to\infty} \frac{1}{T} \sum_{t=0}^{T-1} \mathbb{E}\left[f(\gamma_t)\right]$$

$$\text{s.t.} \quad \frac{1}{W} \sum_{i=t-\min(t,W-1)}^{t} c_i(\gamma_i) \le \overline{C}, \qquad \forall t \ge 0$$

$$\gamma_t \ge \rho\overline{C}, \qquad \forall t \ge 0.$$

$$0 \le c_t(\gamma_t) \le \gamma_t, \qquad \forall t \ge 0.$$

ensure traffic control is not too low

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Some refs

- Zhang, Yunchuan; Simeone, Osvaldo; Jose, Sharu Theresa; Maggi, Lorenzo; Valcarce, Alvaro; **Bayesian and Multi-Armed Contextual Meta-Optimization for Efficient Wireless Radio Resource Management**, IEEE Transactions on Cognitive Communications and Networking, 2023
- Maggi, Lorenzo; Mihailescu, Claudiu; Cao, Qike; Tetich, Alan; Khan, Saad; Aaltonen, Simo; Koblitz, Ryo; Holma, Maunu; Macchi, Samuele; Ruggieri, Maria Elena. **Energy savings under performance constraints via carrier shutdown with Bayesian learning**, 2023 Joint European Conference on Networks and Communications & 6G Summit (EuCNC/6G Summit), 1-6, 2023
- Maggi, Lorenzo; Koblitz, A Ryo; Zhu, Qiping; Andrews, Matthew. **Tracking the Best Beam for a Mobile User via Bayesian Optimization**. 2023 IEEE 97th Vehicular Technology Conference (VTC2023-Spring), 1-7, 2023, IEEE
- Maggi, Lorenzo; Valcarce, Alvaro; Hoydis, Jakob. **Bayesian optimization for radio resource management: Open loop power control**. IEEE Journal on Selected Areas in Communications 39 (7), 1858-1871, 2021

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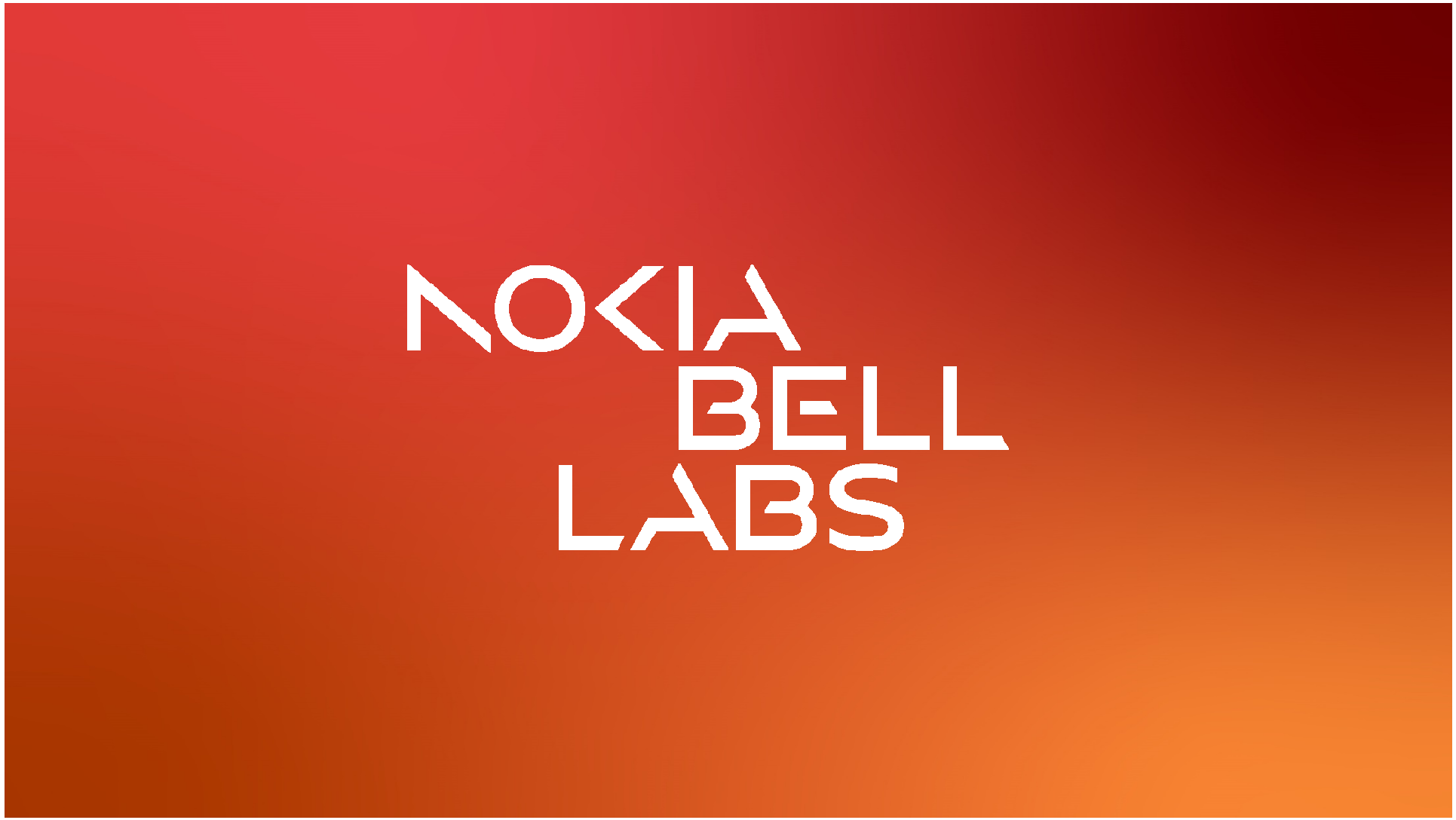
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