Multiple Target Discovery and Coverage with Mobile Wireless Sensors

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Milan Erdelj and Tahiry Razafindralambo
INRIA Lille - Nord Europe

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Mobile sensor/robot deployment

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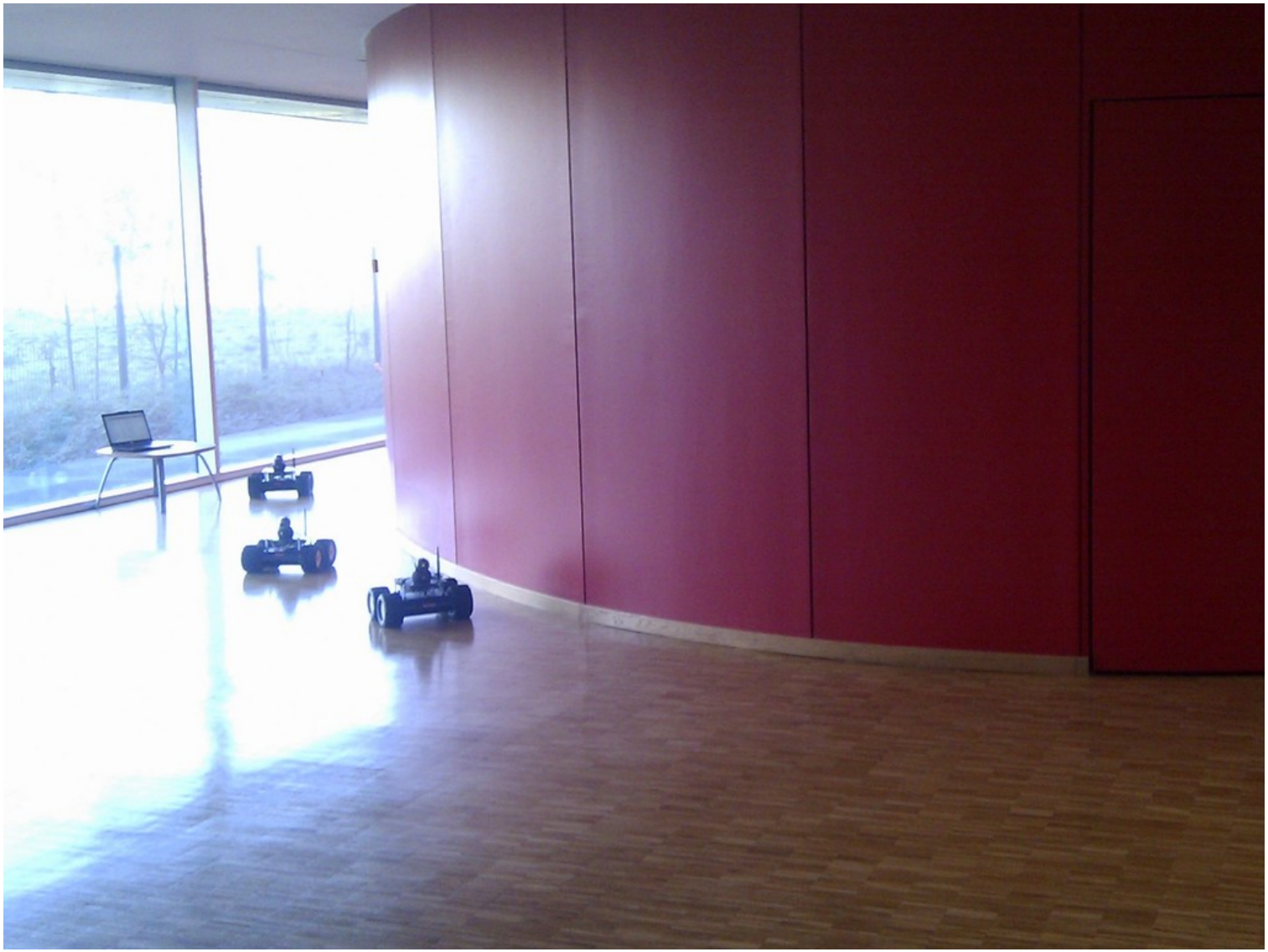

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Contents

Scenario of environmental monitoring

- There are one or more targets in the field of interest at unknown locations
- All available sensors are placed in the vicinity or each other around the gathering point - base station
- The goal is to observe/cover as many targets as possible and transfer gathered data to the base station in multi-hop manner

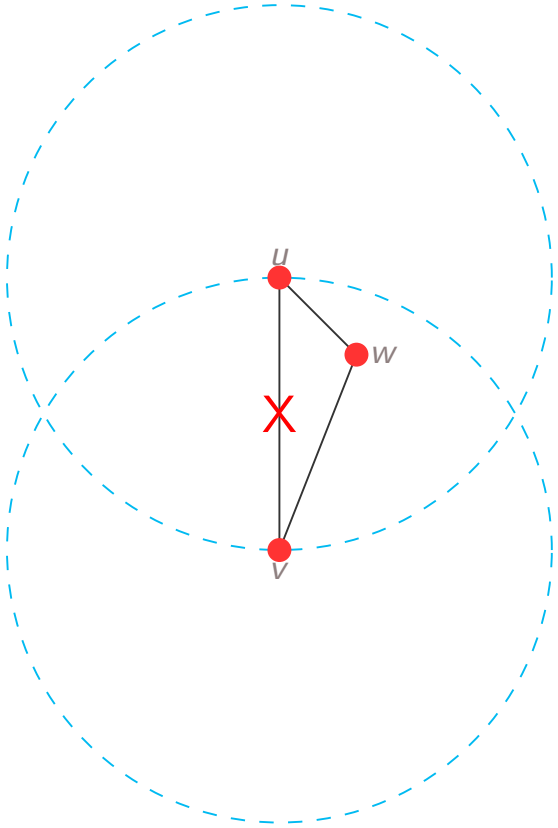
Environment exploration problem

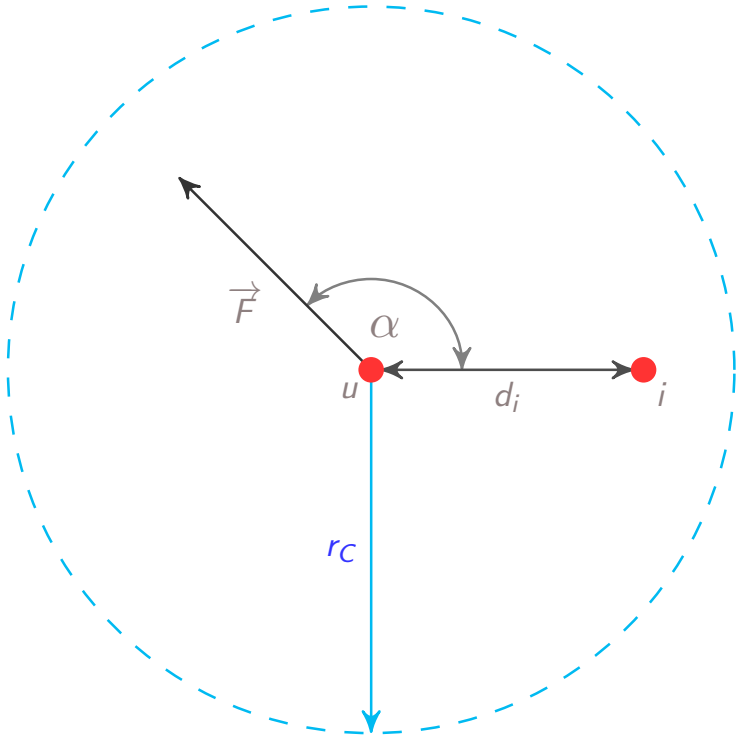
- Unknown deployment field
- Where are the targets and how many of them?
- Connectivity preservation

Target coverage problem

- Distributed solution to cope with the scalability issues
- Connectivity preservation throughout the deployment
- Minimized number of relay sensors, maximized number of covering sensors

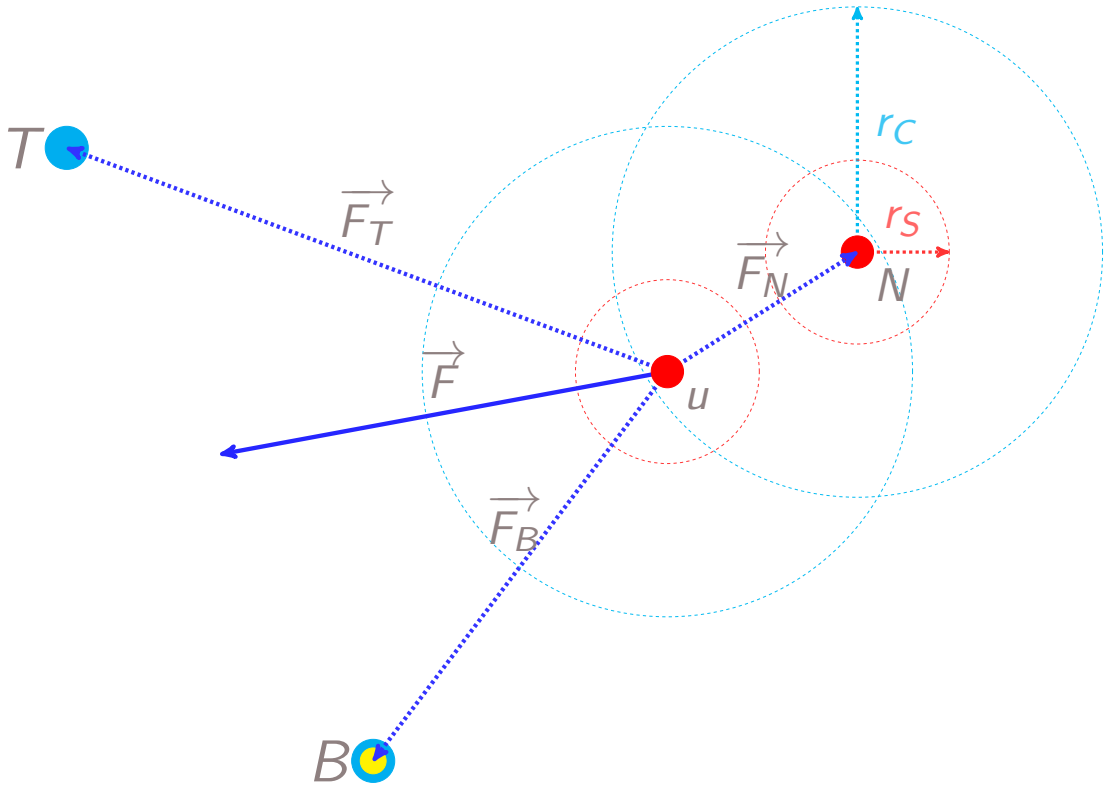
Connectivity preservation





$$d_{max} = \min\{(r_C \cos\alpha_i + \sqrt{d_i^2 - r_C^2 \sin^2\alpha_i})/2, i \in RNG(u)\}$$

Virtual force based movement

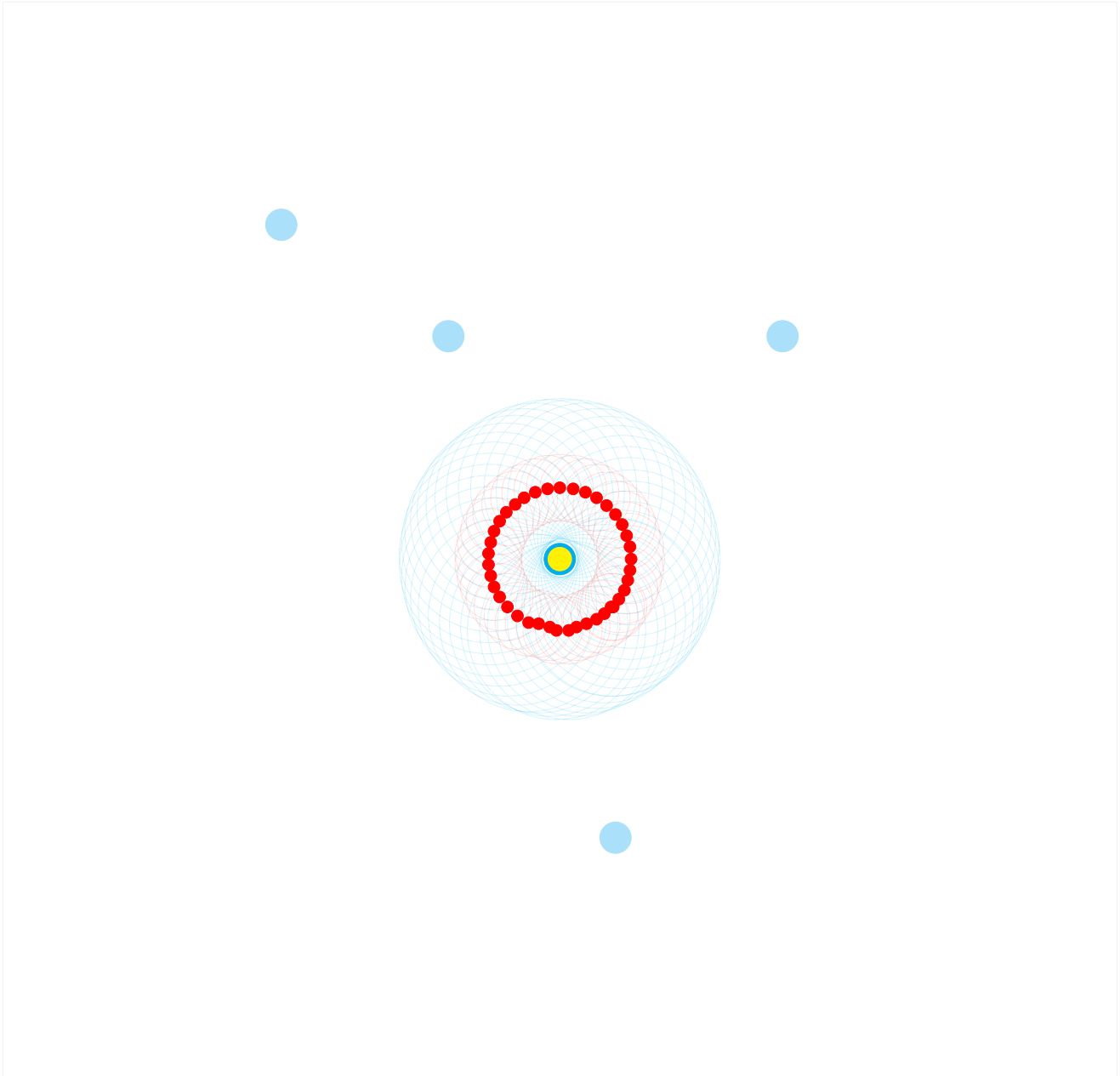


Movement vector $\overrightarrow{F} = \overrightarrow{F_B} + \overrightarrow{F_T} + \overrightarrow{F_N}$

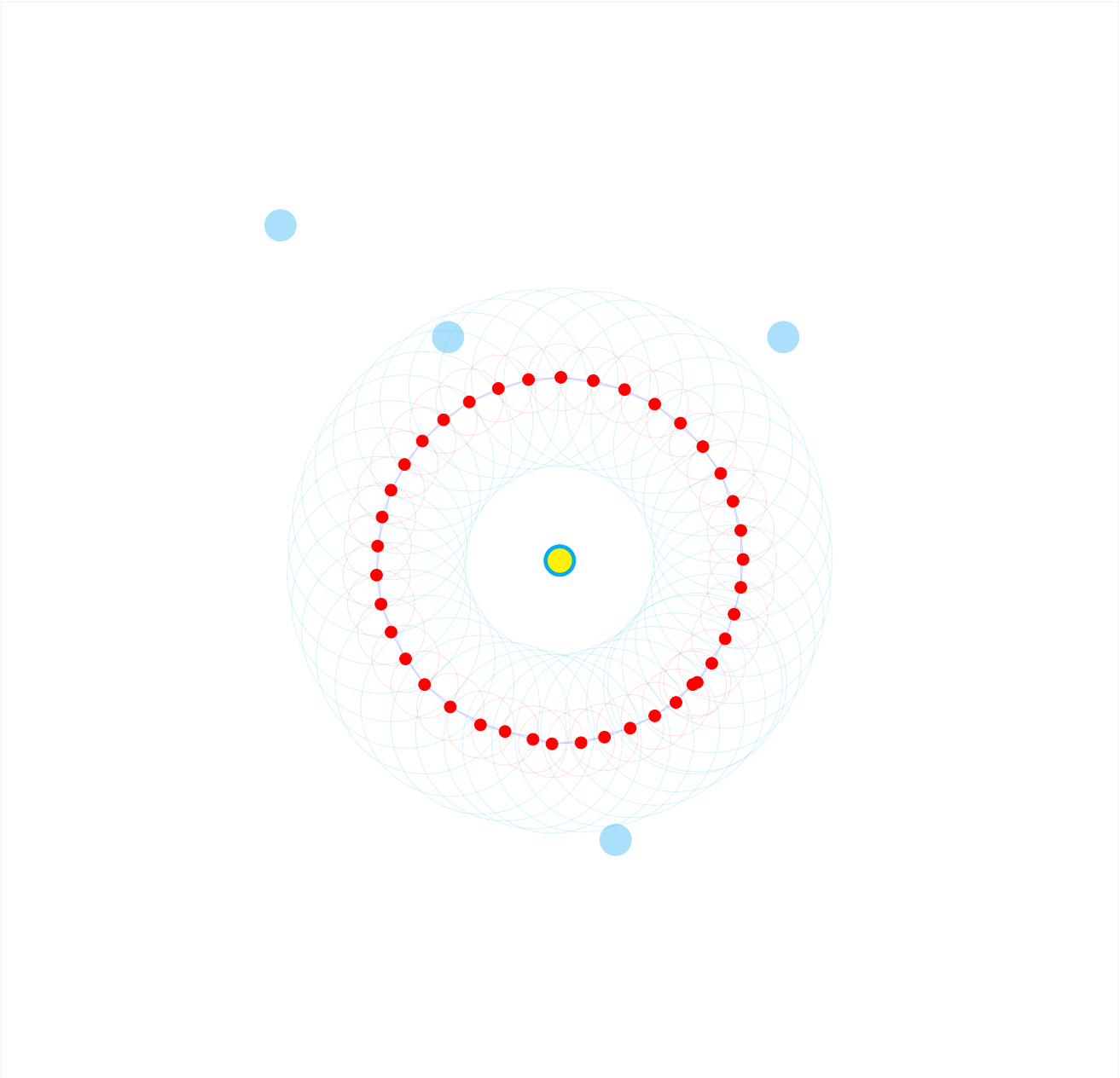
Deployment algorithm

Phase = Discovery;
repeat
  Calculate the $RNG(u)$;
  if *Phase == Discovery* **then**
    $\overrightarrow{F} = \overrightarrow{F_D} = -C_B\overrightarrow{j_B} - \sum_{i=1}^{n_{RNG}} \frac{C_N}{d_i^2}\overrightarrow{j_i}$;
    if *Target is discovered* **then**
      Add $T_i(x, y)$ in the neighborhood table;
      Share $T_i(x, y)$ information with neighbors;
  else
    if *Covering the target* **then**
      $\overrightarrow{F} = \overrightarrow{F_C} = \frac{C_T}{d_T^2}$;
    else
      $\overrightarrow{F} = \overrightarrow{F_C} = C_B\overrightarrow{j_B} + \frac{C_T}{d_T^2}\overrightarrow{j_T} + \sum_{i=1}^{n_{RNG}} C_N d_i \overrightarrow{j_i}$;
  $d_{max} = \min\{\frac{r_C\cos\alpha + \sqrt{d_i^2 - r_C^2\sin^2\alpha}}{2}, i \in RNG(u)\}$;
  if $d(u, RNG(u)) == 2r_S$ **then**
    Phase = Coverage;
until *Target is covered* ;

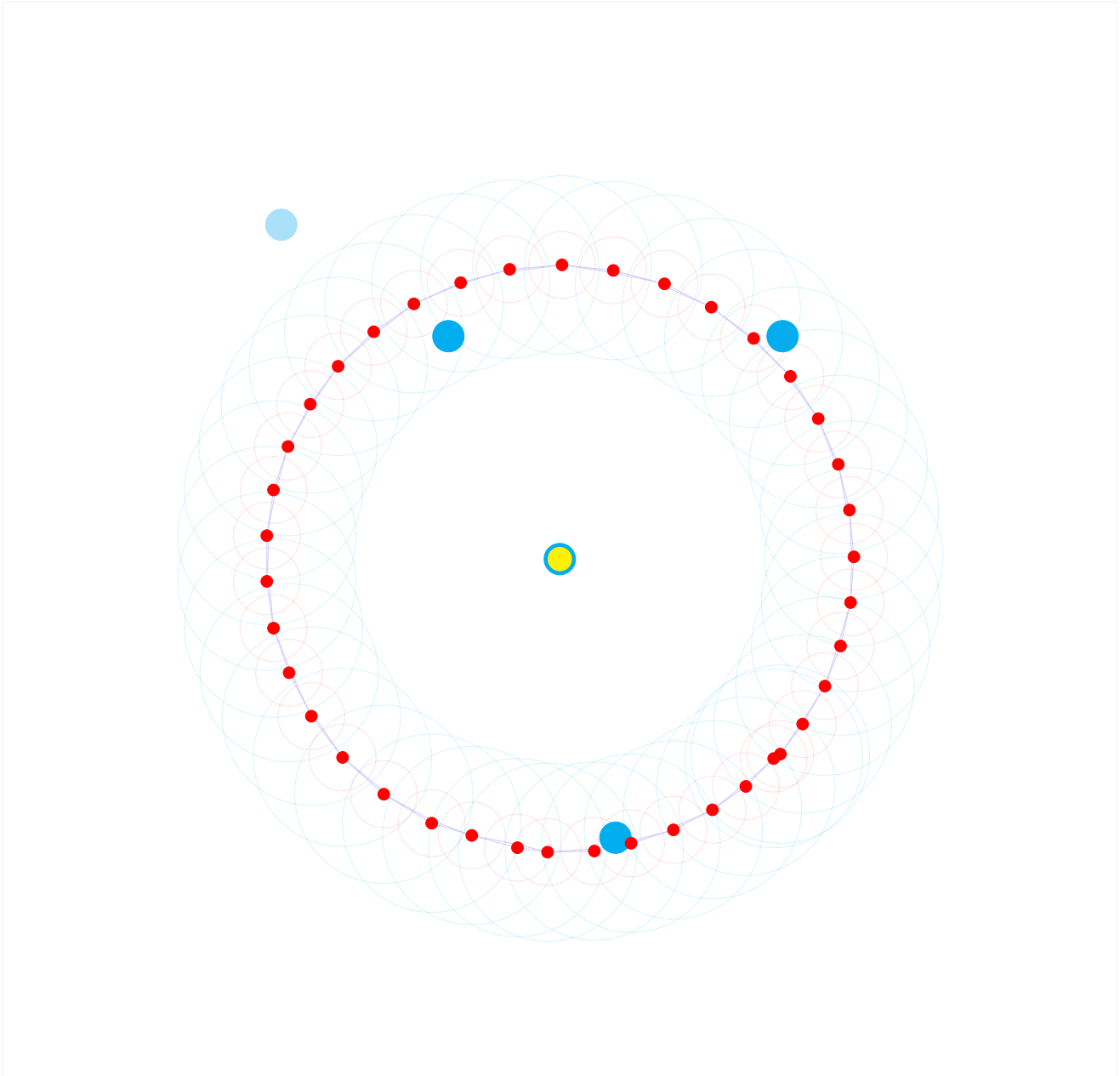
Discovery



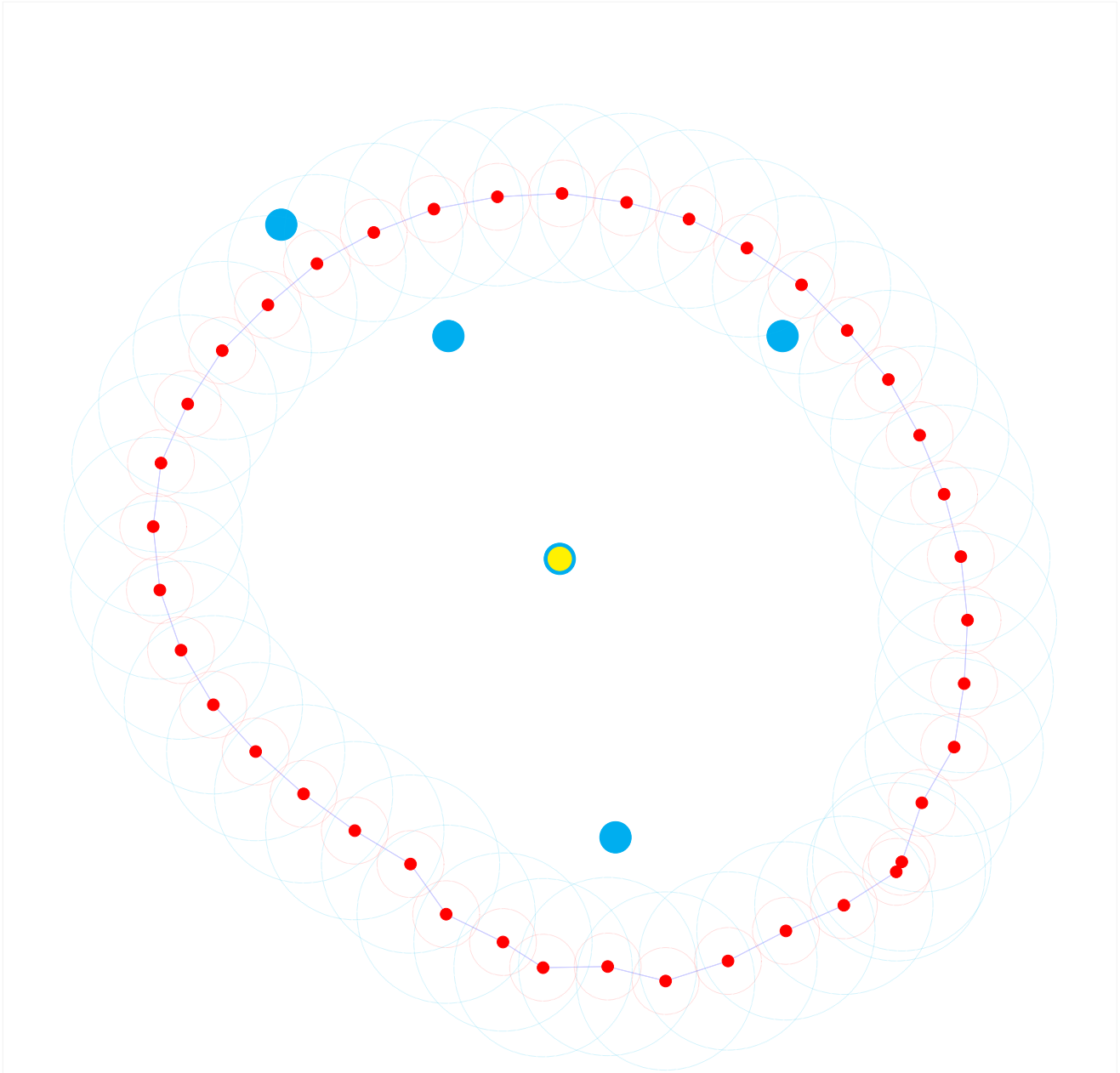
Discovery



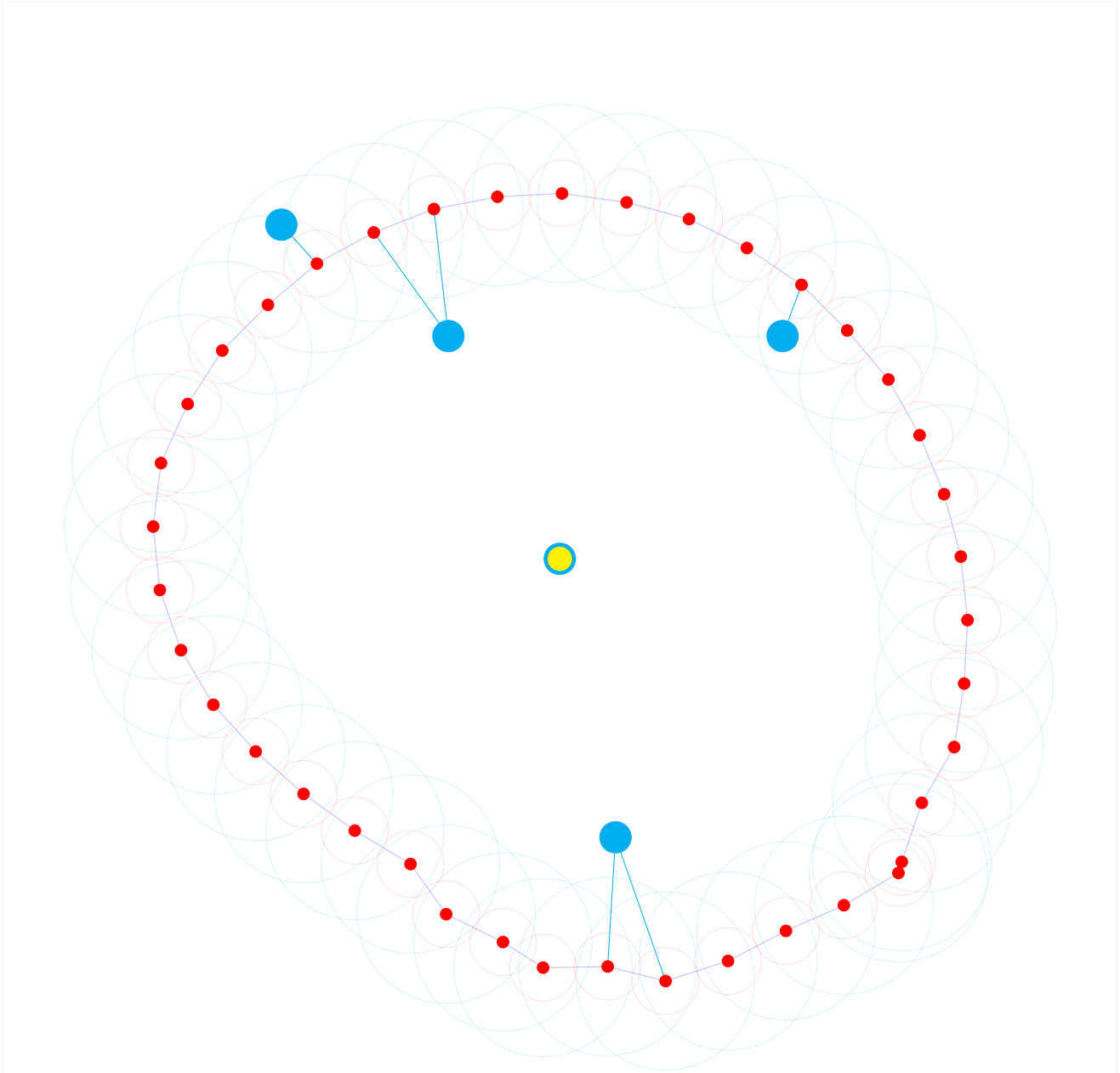
Discovery



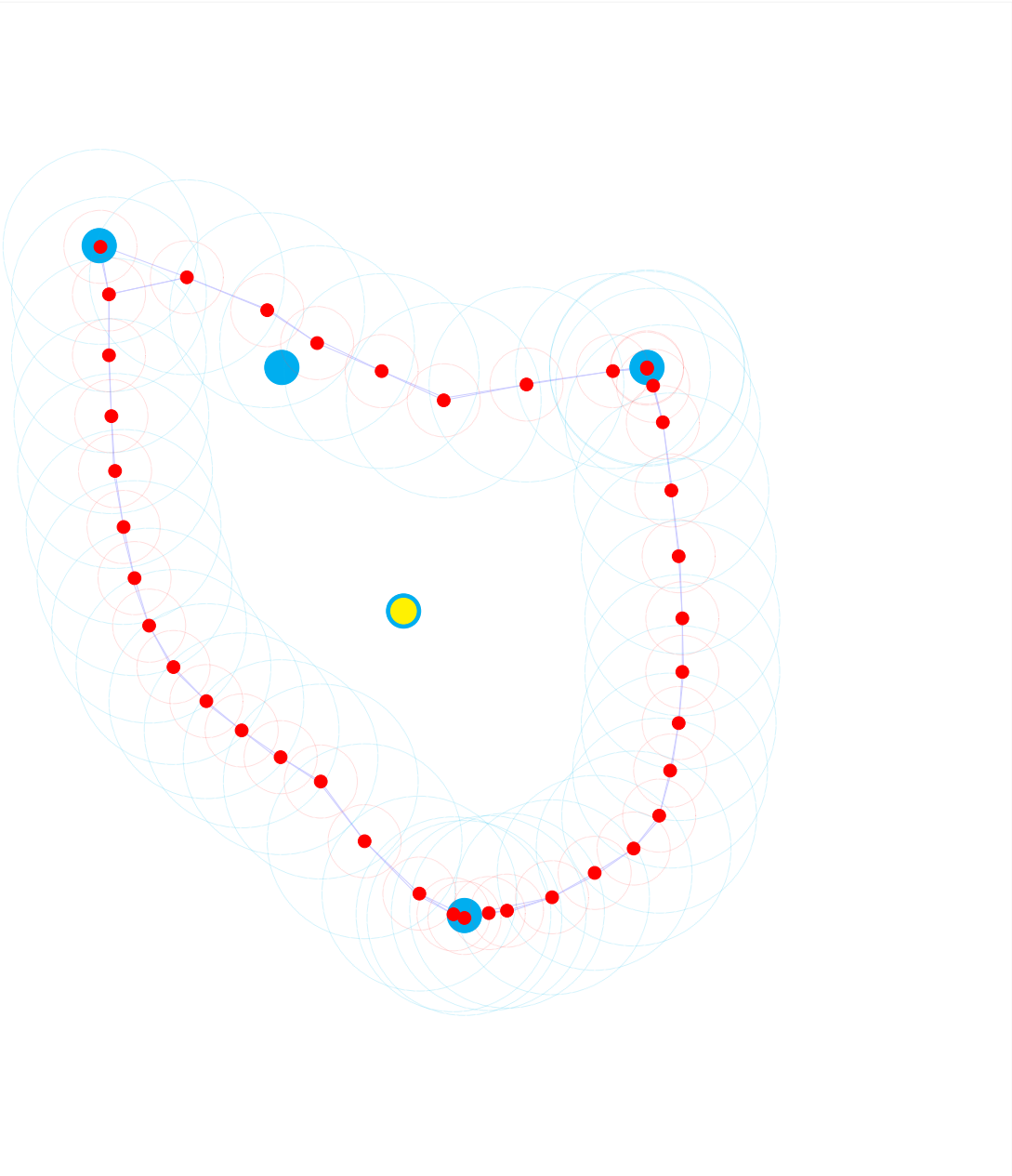
Discovery



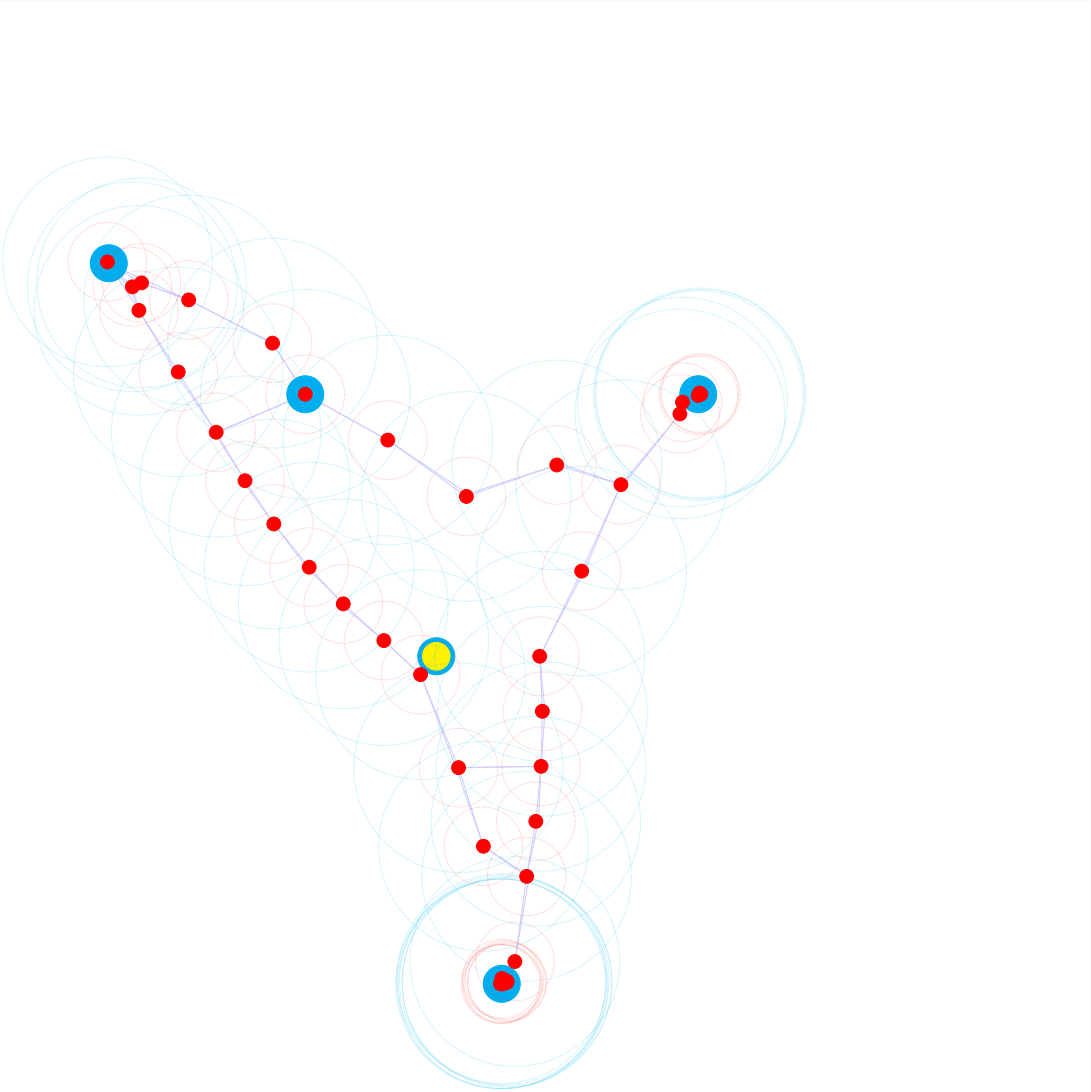
Coverage



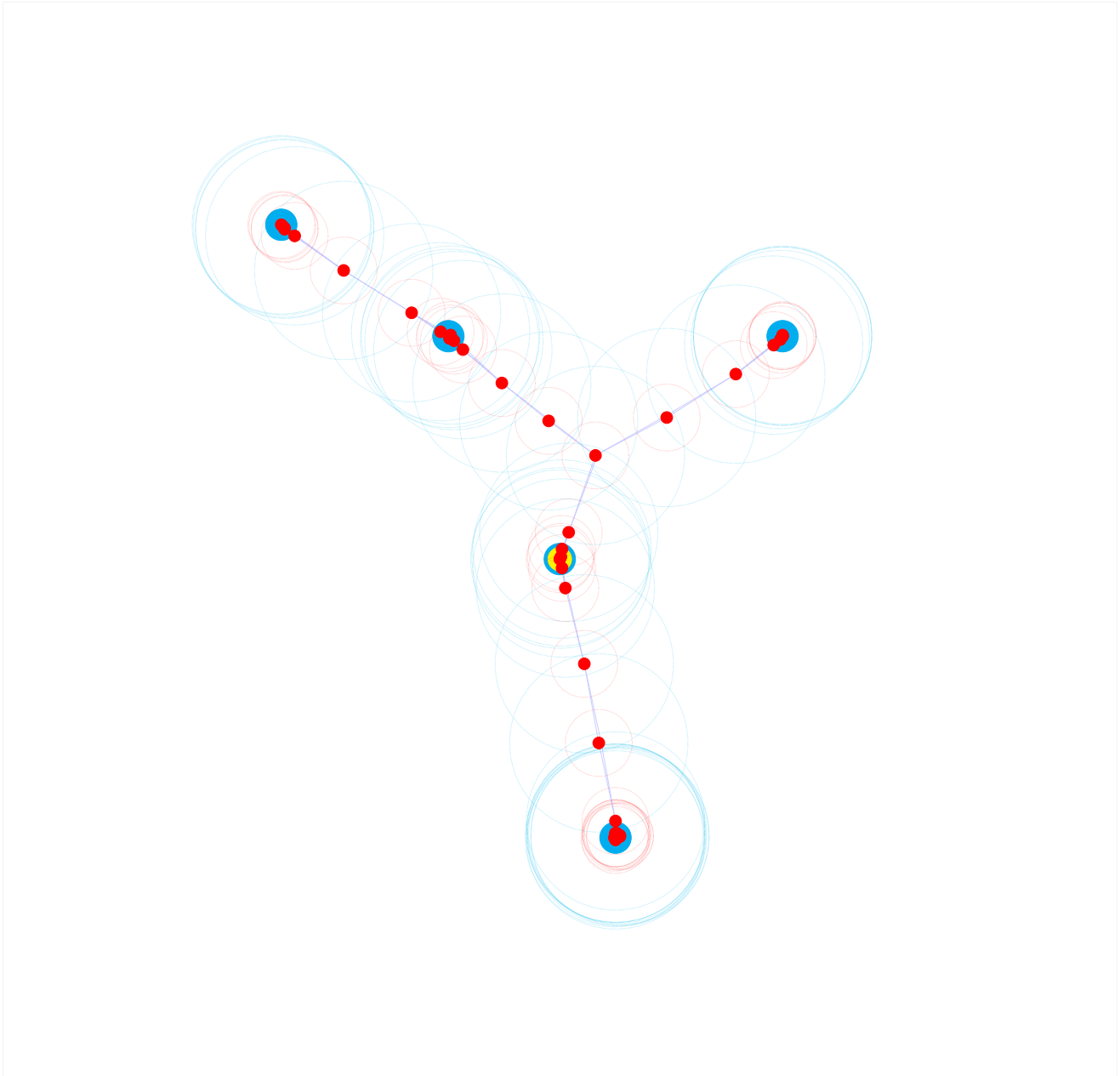
Coverage



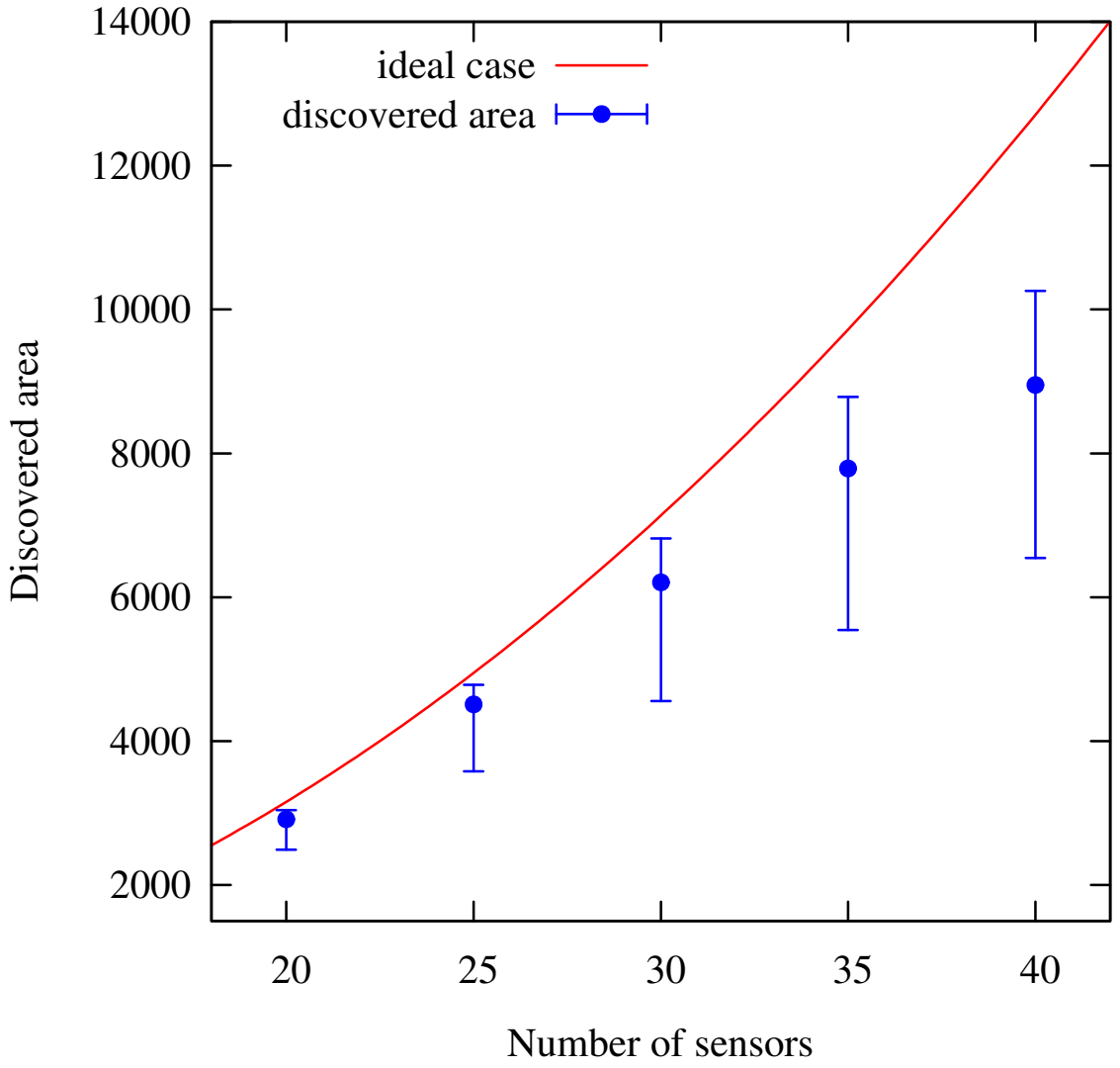
Coverage



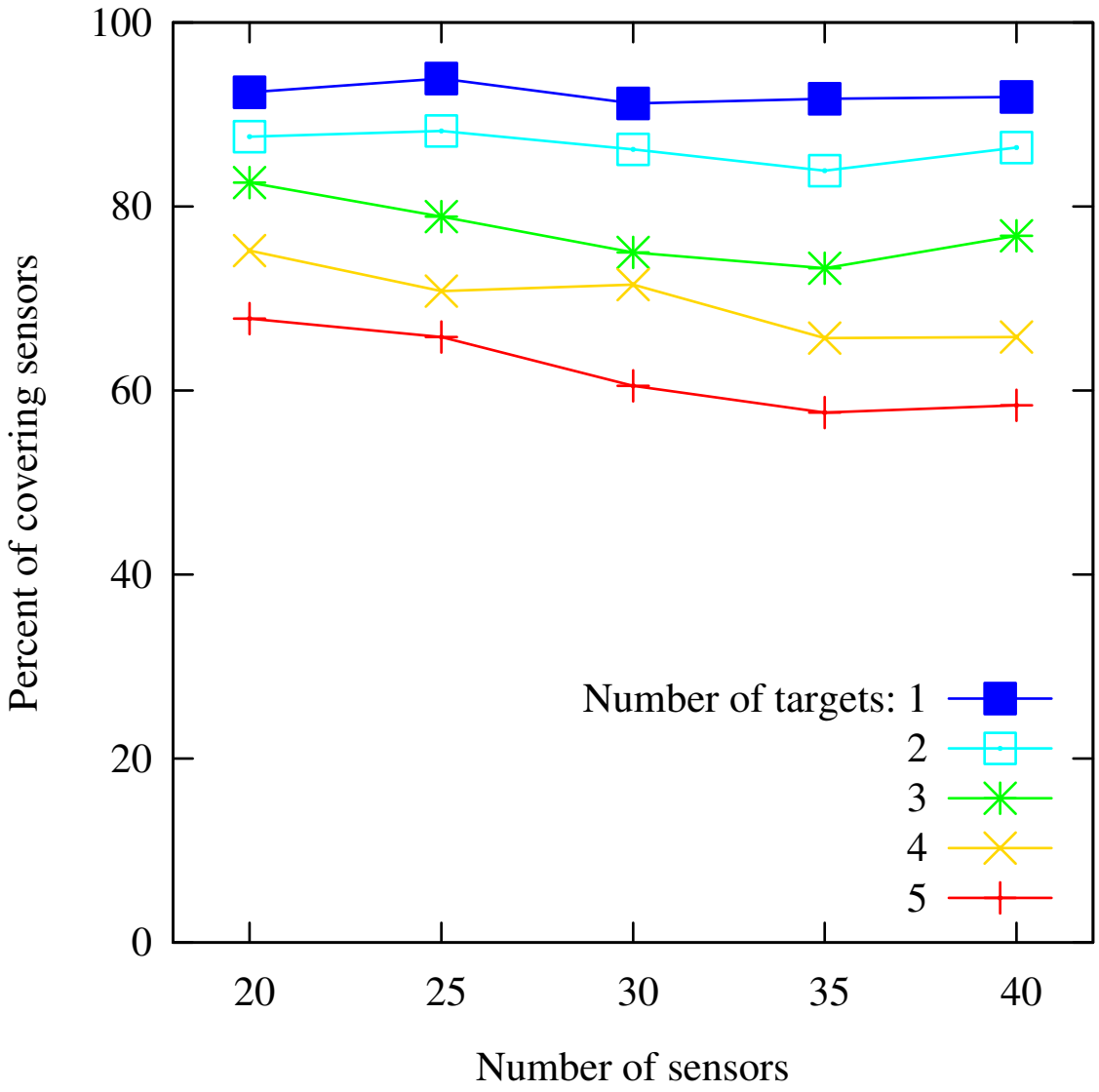
Coverage



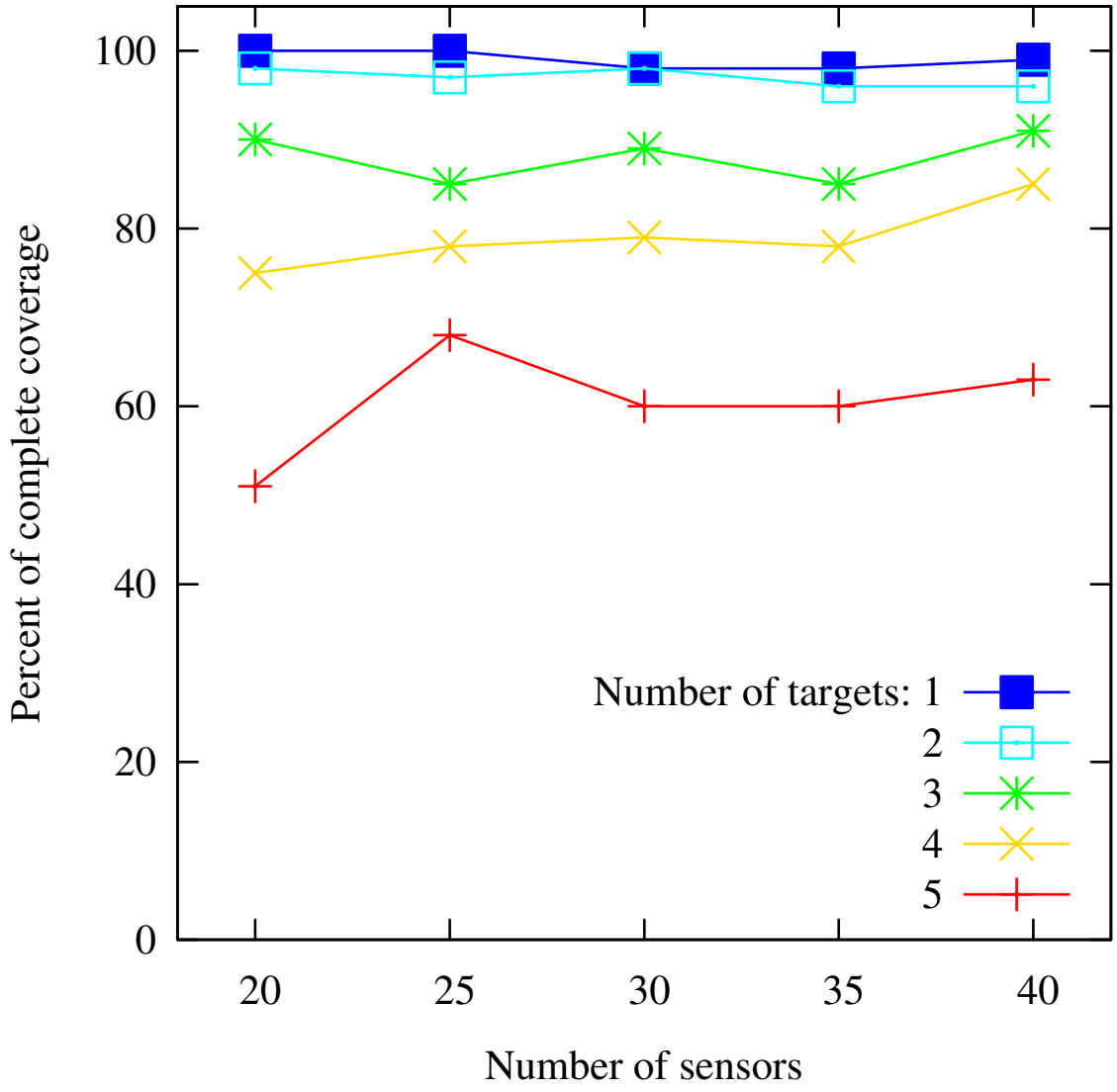
Discovered area



Percent of covering sensors



Percent of complete coverage



Conclusions - Pros

- Distributed asynchronous algorithm for target coverage which maximizes the number of covering and minimizes the number of connectivity sensors
- The same principle used both for exploration and coverage
- The connectivity between sensors is preserved all throughout the deployment
- The network adapts itself to the indoor environment shape

Conclusions - Cons

- Coverage phase convergence - does it always form a tree?
- What happens if a node dies?
- Mobile targets?

Thank you!