CERIAS

The Center for Education and Research in Information Assurance and Security

FD&C HSL

Robust State Estimation in Multi-Agent Systems using Pairwise Measurements

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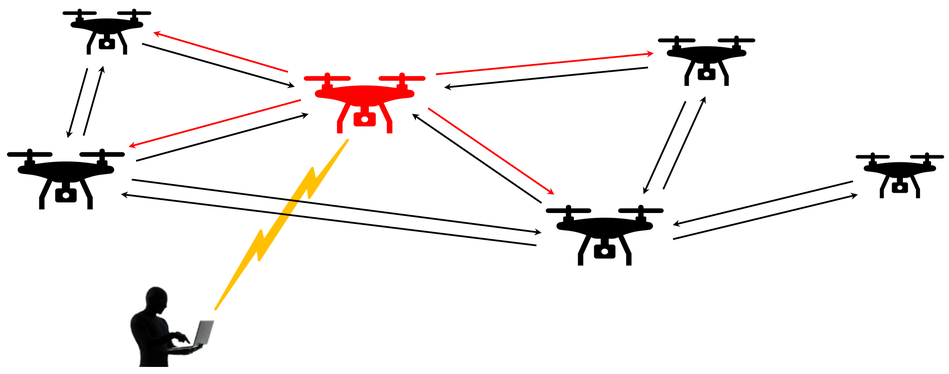
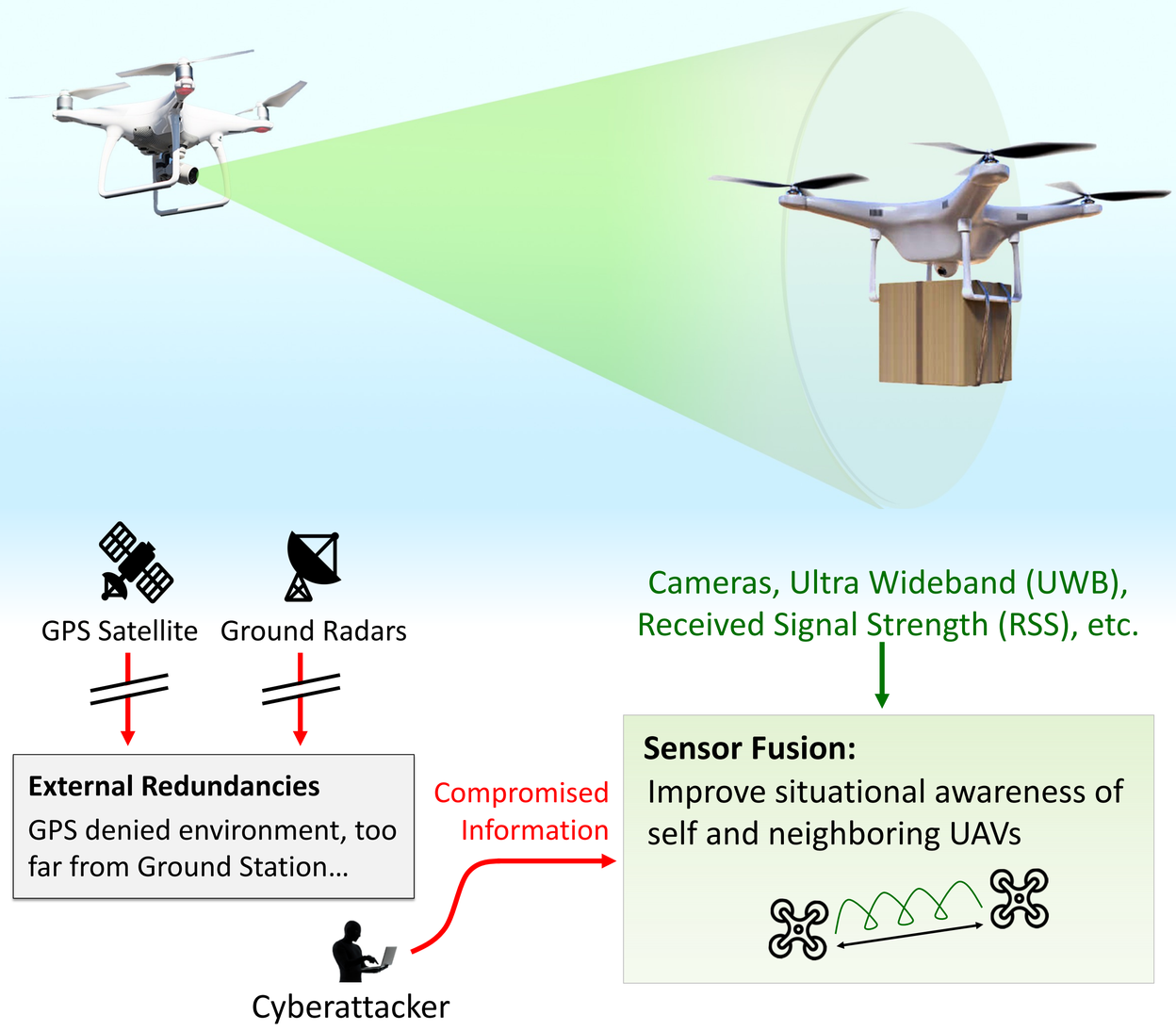
Cybersecurity of Multi-Agent Systems

- **Multi-Agent Systems** (MAS) can accomplish complex missions like search-and-rescue and remote sensing
- Close integration with human life and property makes **safety assurance** of utmost importance
- Each agent of the MAS uses a mix of onboard sensors (INS, cameras) and communications (GPS, radio, Wi-Fi) to navigate the environment safely
- Cyberattackers can exploit vulnerabilities of onboard sensors and communications to compromise the collective performance of the MAS:

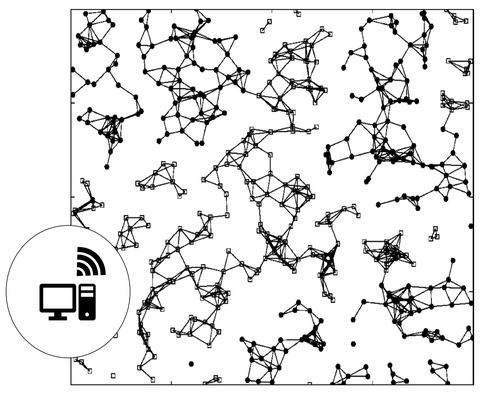




- **Expensive Solution:** Install additional sensors, using data-driven approaches (e.g., classification models) to detect cyberattacks and anomalies

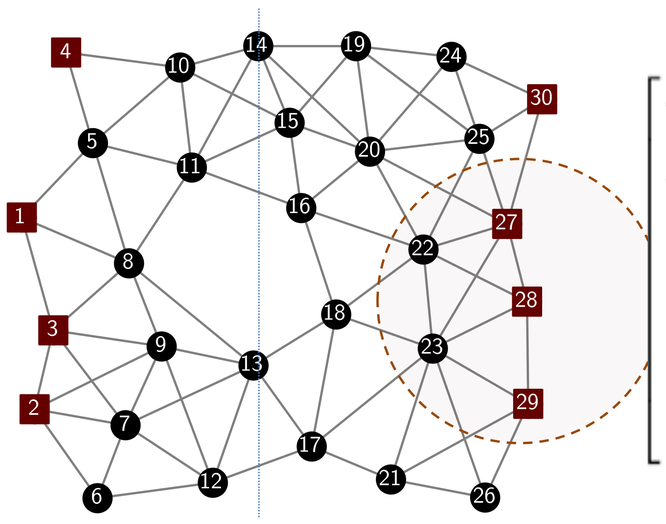
  Proposed Approach: Use the existing **pairwise measurements** (e.g., camera pointed from one agent to another) for real-time detection and mitigation

Scalability Issues in Large-Scale MAS



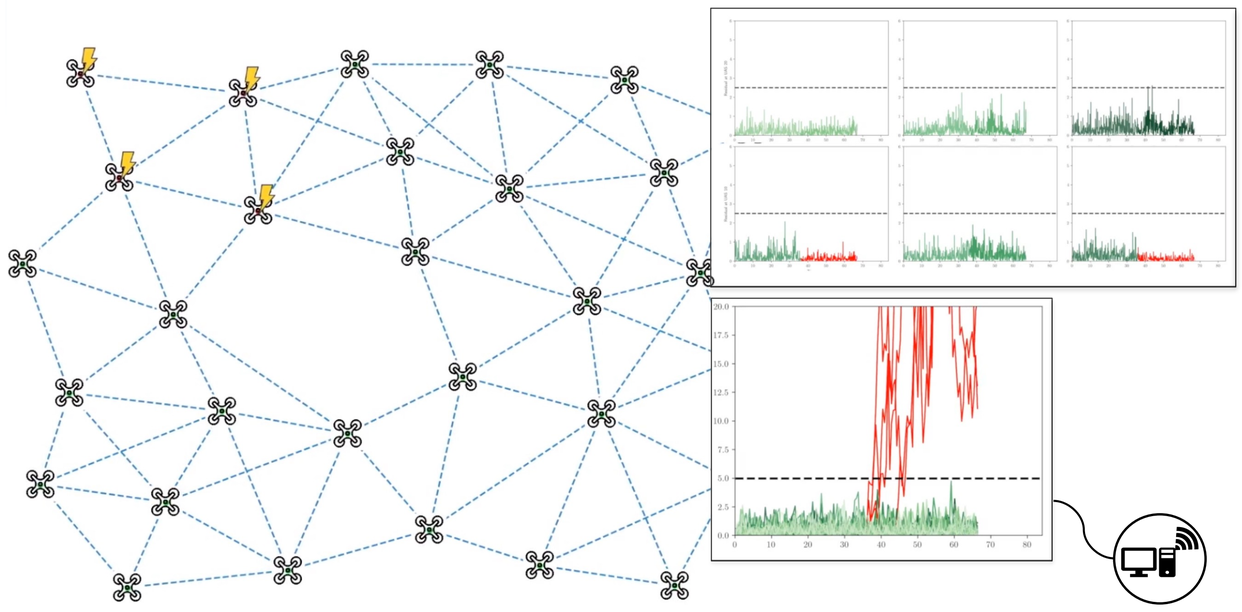
Large amount of data can be processed by:

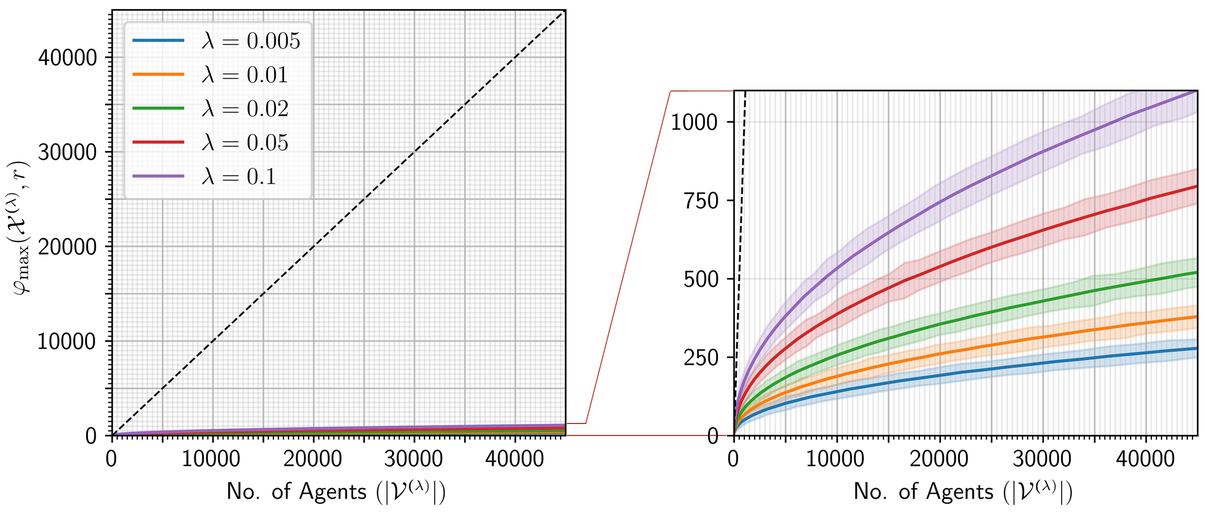
1. exploiting **sparsity**
2. **relaxation / convexification** of the problem
3. **distributed algorithms**



$$\begin{bmatrix} B_{11} & B_{12} & 0 & \cdots & \cdots & 0 \\ B_{21} & B_{22} & B_{23} & \ddots & \ddots & \vdots \\ 0 & B_{32} & B_{33} & B_{34} & \ddots & \vdots \\ \vdots & \ddots & B_{43} & B_{44} & B_{45} & 0 \\ \vdots & \ddots & \ddots & B_{54} & B_{55} & B_{56} \\ 0 & \cdots & \cdots & 0 & B_{65} & B_{66} \end{bmatrix}$$

$$\begin{aligned} \underset{a_i}{\text{minimise}} \quad & \|[a_1\ a_2\ \ldots]^T\|_{\not 0}^{1} \\ \text{subject to} \quad & \|\hat{x}_i - a_i - (\hat{x}_j - a_j)\| = d_{ij},\ \forall (i,j) \in \mathcal{E} \\ & \|a_i\| \le \bar{a},\ \forall i \end{aligned}$$





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