CERIAS

The Center for Education and Research in Information Assurance and Security

Strategic Security Resource Allocation for Internet of Things

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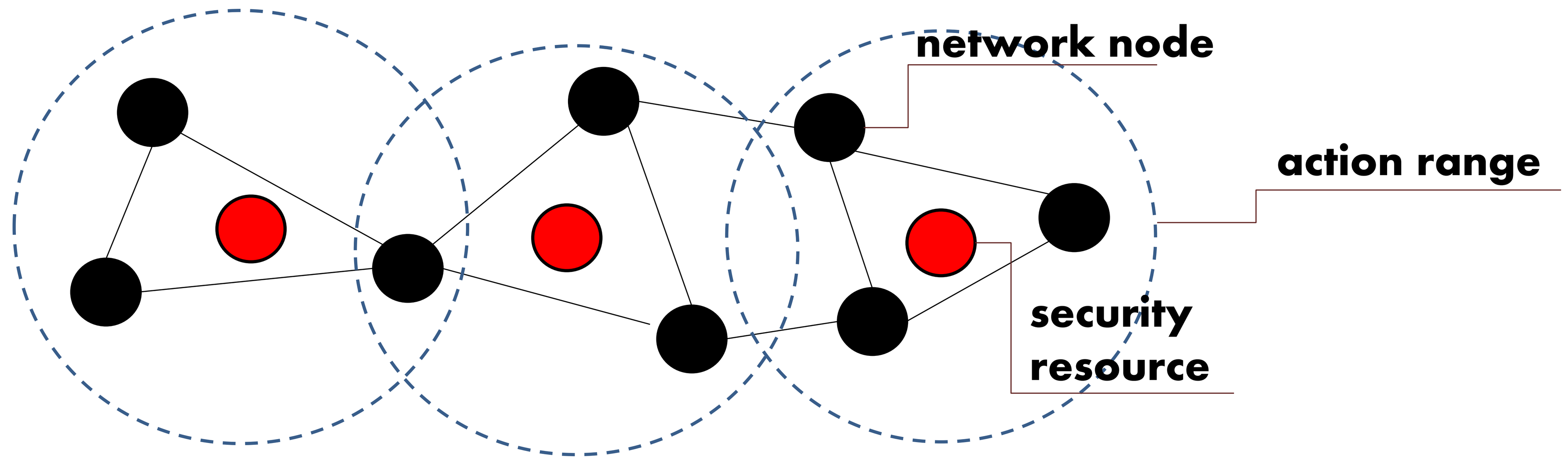
Problem

In an IoT scenario, given a set of security resources and a set of attacks to protect against, which resources should a security manager choose, and how should (s)he allocate them in the network in order to ensure protection with the minimum cost, the minimum energy consumption, and a certain degree of robustness against attacks?



SECURITY RESOURCES:

- intrusion detection systems;
- attack prevention systems;
- directional antennas and highly sensitive transceivers;
- tamper resistant hardware;
- additional nodes.

Definitions

DEFENDER STRATEGY EFFICIENCY: is based on the total **energy consumption** of the security infrastructure and the **costs of its components**.

DEFENDER STRATEGY EFFECTIVENESS: is based on two metrics: **risk**, defined as the maximum number of network nodes that are no longer protected when an attacker succeeds in taking down at least one security resource; **criticality**, a measure of how critical certain nodes are for the correct operation of the network.

SECURITY SYSTEMS: we classify security systems into two main categories: **detection and prevention systems**. Those categories correspond to two different security policies: (i) **node/link monitoring**, and (ii) **node/link hardening**.

SECURE NODE: a network node **n** is secure if at least one of the following conditions holds:

1. **n** is tamper resistant;
2. every **link** that involves **n** is secure.

SECURE LINK: a link **{n,n'}** is secure if at least one of the following conditions holds:

1. both nodes **n** and **n'** are in the action range of the same watchdog;
2. both nodes **n** and **n'** can establish a secure communication channel.

SECURE NETWORK: a network is secure if all the network nodes are secure according to the definition of secure node.

Players

DEFENDER: The defender strategy consists of a **security resource allocation plan**. The best plan is computed **in two steps**. The **first step** consists of a **Pareto analysis** which solves the optimization problem defined by the following equation:

$$\min_{AP \in \mathcal{AP}} \{ec(AP), tc(AP), \max_{sr \in AP} crit(sr, AP, N)\}$$

The **second step** computes the best allocation plan (best defender strategy), by solving the optimization problem defined by the following equation:

$$\min_{AP \in AP+} \{\max_{sr \in AP} risk(sr, AP, N)\}$$

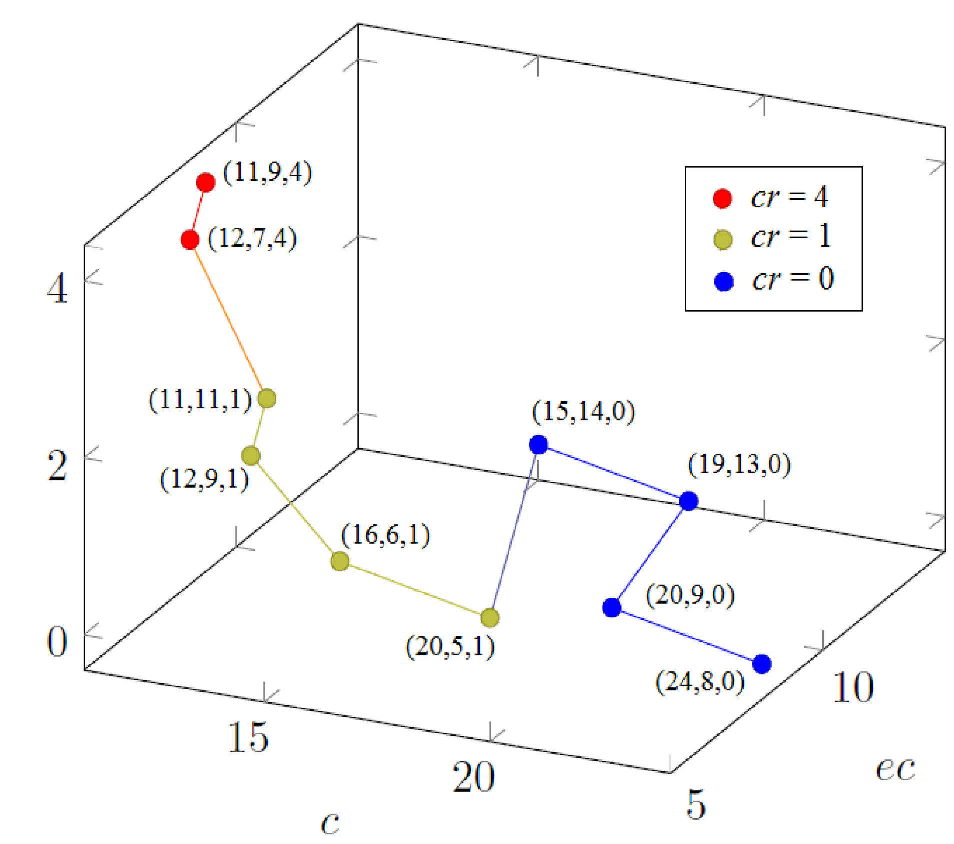
ATTACKER: can physically **tamper** with the network nodes, **capture** and **reprogram** legitimate nodes and security resources, and **add malicious entities** to **overhear** data, **inject** false data, **drop data packets**, introduce **interference**, claim **multiple identities.** The attacker needs to compromise at least one security resource in order to carry out an attack.

$$sr^* = \max_{sr \in AP} \alpha \cdot risk(sr, AP, N) + \beta \cdot crit(sr, AP, N)$$

Algorithm

Algorithm 1

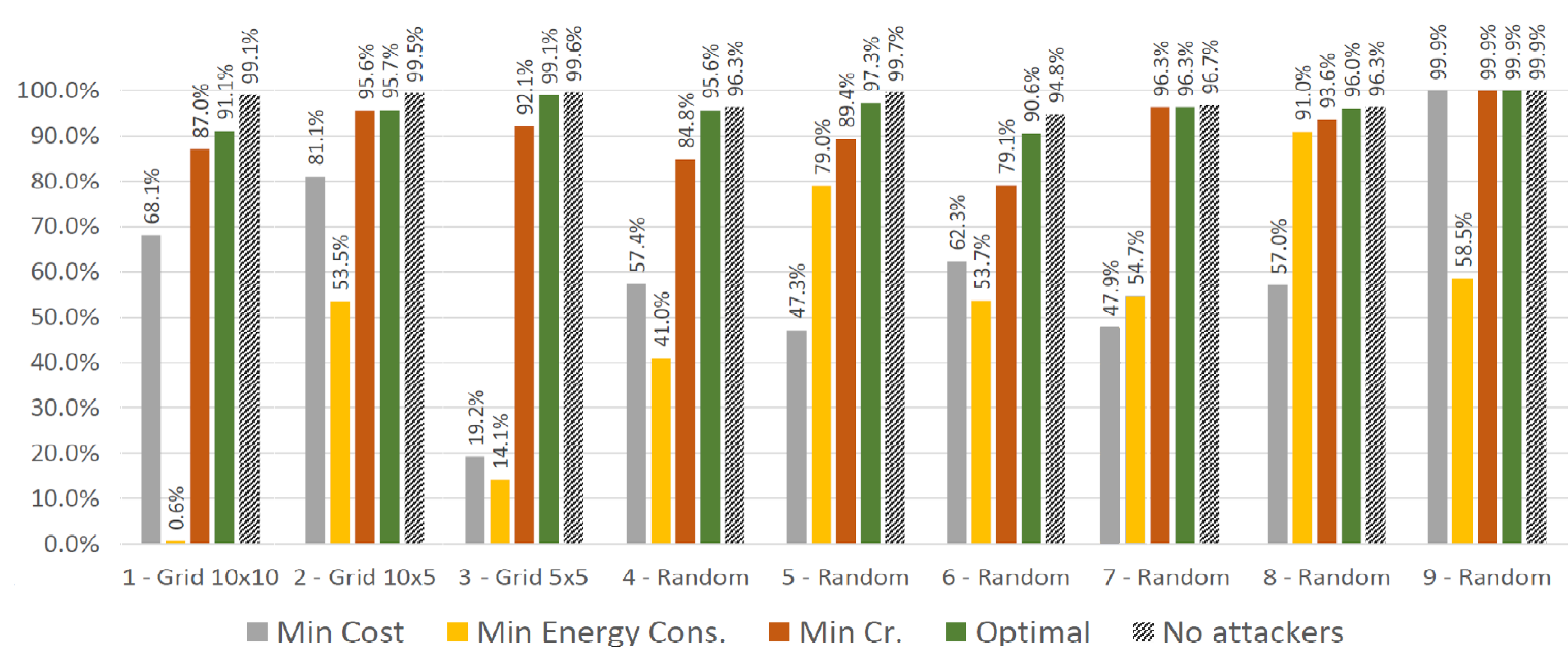
procedure ComputePC(minCR,maxCR)
  for $cr = minCR\text{-}1, \ldots, maxCR$ **do**
    $tc \leftarrow getTC(\infty, cr)$;
    while $(tc \neq null)$ **do**
      $ec \leftarrow getEC(tc, cr)$;
      $X \leftarrow X \cup (ec, tc, cr)$;
      $tc \leftarrow getTC(ec, cr)$;
    end while
  end for
  return Pareto-optimal points in X;
end procedure



$$getEC(tc, cr) = \min_{\substack{AP \in \mathcal{AP} \\ tc(AP) \leq tc \\ \max_{sr \in AP} crit(sr, AP, N) \leq cr}} ec(AP)$$

$$getTC(ec, cr) = \min_{\substack{AP \in \mathcal{AP} \\ ec(AP) < ec \\ \max_{sr \in AP} crit(sr, AP, N) \leq cr}} tc(AP)$$

Experimental Results



The best defender strategy provide a higher packet delivery rate w.r.t the most cheap strategy and the less energy consuming strategy.

Our approach provides a high quality defender strategy, for which the minimum cost is used, and that consumes the minimum amount of energy.