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How to improve routing protocol security in a RPAS swarm?

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SUANET project: Secure UAV Ad hoc NETwork
The goal of this research is to define and design a secure communication network for UAV swarm. Our objective is to design a new secure routing protocol for UAANET in order to guarantee message authentication between UAVs. This solution needs to minimize signaling overhead in order to preserve network resources for effective data exchanges between UAVs.

This proposed routing protocol called SUAP should be certified. Consequently, we contribute to its validation through the use of MDD (Model Driven Development) approach using a set of formal verification tools (i.e. Mathworks Matlab Simulink and Stateflow software).

SUAP routing
The SUAP (Secure UAV Ad hoc Routing Protocol) algorithm consists of 2 steps used respectively during route maintenance and route discovery:

1. **Enhanced Beacon messages:** we use a mechanism that mathematically analyzes the correlation between the hop count and the distance traveled by Hello packets and Error packets.

\[
\frac{T}{D_{max}} - 1 < \frac{T}{D_{max} + 1}
\]

- \( T \): total distance of the legitimate route
- \( D_{max} \): maximum distance of one hop

2. **Secure route discovery:**

The source node appends its own address and the next node address to the hash chain called Hashnew. It also includes the Hashold (which is the previous Hashnew) within the packet.

UAANET use case
The main use case scenario identified in this project is a search and rescue application where one UAANET swarm is used to cartography and analyze a physical area.

Video surveillance flows are exchanged between UAVs of the swarm and information is collected through the ground control station.

UAANET model of attack
One of the major issues with UAV communication security is to face the Wormhole attack where two attackers perform a tunnel in an existing UAANET configuration. These attackers take place in the network as legitimate nodes and exchange information by stealing resources and connections of real legitimate nodes. The purpose of SUAP algorithm is to secure the routing protocol of the UAANET against different network attacks (in particular the Wormhole).

Experimental results: we compared our SUAP protocol to AODV routing protocol (one of the routing protocol reference in MANET environments). Our experiments perform that SUAP is able to increase drastically both the quality of transmission and security of communication.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>AODV</th>
<th>SUAP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average loss duration</td>
<td>7.34 s</td>
<td>2.04 s</td>
</tr>
<tr>
<td>Packet delivery ratio</td>
<td>40.5 %</td>
<td>95 %</td>
</tr>
<tr>
<td>Average end to end delay</td>
<td>5.11 ms</td>
<td>35.11 ms</td>
</tr>
<tr>
<td>Connectivity percentage</td>
<td>9.8 %</td>
<td>90 %</td>
</tr>
</tbody>
</table>

Conclusion and future works
The SUANET project enables a new secure UAANET routing protocol providing message authentication, detection and prevention against Wormhole attacks. Some additional benefits include:

- A safe routing protocol designed with MDD approach and verified through a set of formal verification tools;
- Evaluation through UAANET emulation and real world experiments;
- Our future works consist to:
  - Define a key management mechanism to enable deployment of multiple keys which will be used to implement authentication, confidentiality and integrity services.
  - Perform an extended real world outdoor experiments with several UAVs and GCS.