Virtual middleboxes are becoming increasingly attractive because of the flexibility and agility they enable. Several frameworks (e.g., Stratos, SIMPLEX) have been developed for managing the composition and provisioning of virtual middleboxes. However, control over how middleboxes examine and modify network traffic is limited: policies and parameters are manipulated using narrow, middlebox-specific interfaces, while internal algorithms and state are completely inaccessible and unmodifiable. A lack of fine-grained control over middleboxes and their state precludes correct and well performing implementation of control scenarios that involve re-allocating live flows across middleboxes: e.g., horizontal scaling.

**MIDDLEBOX STATE TAXONOMY**

<table>
<thead>
<tr>
<th>Role</th>
<th>Definition</th>
<th>IPS Examples</th>
<th>Partitioning</th>
<th>Operations</th>
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<td>Configuration</td>
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<td>Rules, alert level</td>
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<td>Middlebox reads</td>
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<td>Reporting</td>
<td>Quantifies observations</td>
<td>Packet counters, alert logs</td>
<td>Per-flow &amp; shared</td>
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</tbody>
</table>

**SDMBN ARCHITECTURE**

1) High-level operation to move state
2) Controller issues a get request
3) Send the requested state
4) Insert the state
5) Issue re-processing event to ensure atomic state change
6) Reprocess packet to update state
7) Update the route
8) Remove moved state

**RIBOURL bounds API**

Implemented live migration and scaling control applications on top of northbound API

**SOUTHBOUND API**

- State Interface
  - Desire to conceal state structure and protect its integrity
  - Need to move, clone, and merge state at fine granularity
- Modified Bro, PRADS, and SmartRE to support southbound API

**EVALUATION**

Controller handles operations efficiently and is scalable

**REFERENCES**
