Embedded Transport Agents for Near-Earth Communications

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Objective

- Enhance TCP behavior for near-Earth space communications
  - Create a general, extensible TCP control plane facility (“embedded TCP agents”)
    - User-space, transport-layer tuning/control application
    - Agent-to-agent, reliable transport protocol
    - TCP in-band, secondary data channel (SDC)
    - TCP instrumentation

Objectives

- Enhance TCP behavior for near-Earth space communications
  - Maintain TCP sessions across connectivity loss (“resilient TCP connections”)
  - Retain interoperability with Internet-standard TCP
  - Benefit SCPS-TP
  - Demonstrate feasibility of Embedded TCP Agent concept

Benefits

- Embedded TCP Agent Architecture
  - Embeds greater intelligence into TCP stack
  - Dynamically adapts or tunes TCP's behavior to current or projected conditions
  - Minimizes changes to TCP protocol
  - Hosts TCP intelligence in user-space
  - Enables rapid integration of cutting-edge research results into TCP implementations

Benefits

- Resilient TCP Connections
  - Maintain TCP connections in face of episodic or intermittent connectivity
    - e.g., LEO satellites
    - Extend/clarify RFC 1122, SCPS-TP behaviors
  - Hide intermittent connectivity from applications
    - obviate need to modify applications to handle temporary communications interruptions
  - Provide benefit of resilient TCP connections to *all* TCP users

Benefits

- Interoperability with unmodified TCP implementations
  - Enables a single, enhanced TCP implementation to interoperate with:
    - both enhanced and unmodified partners
    - both terrestrial and near-Earth space partners

Benefits

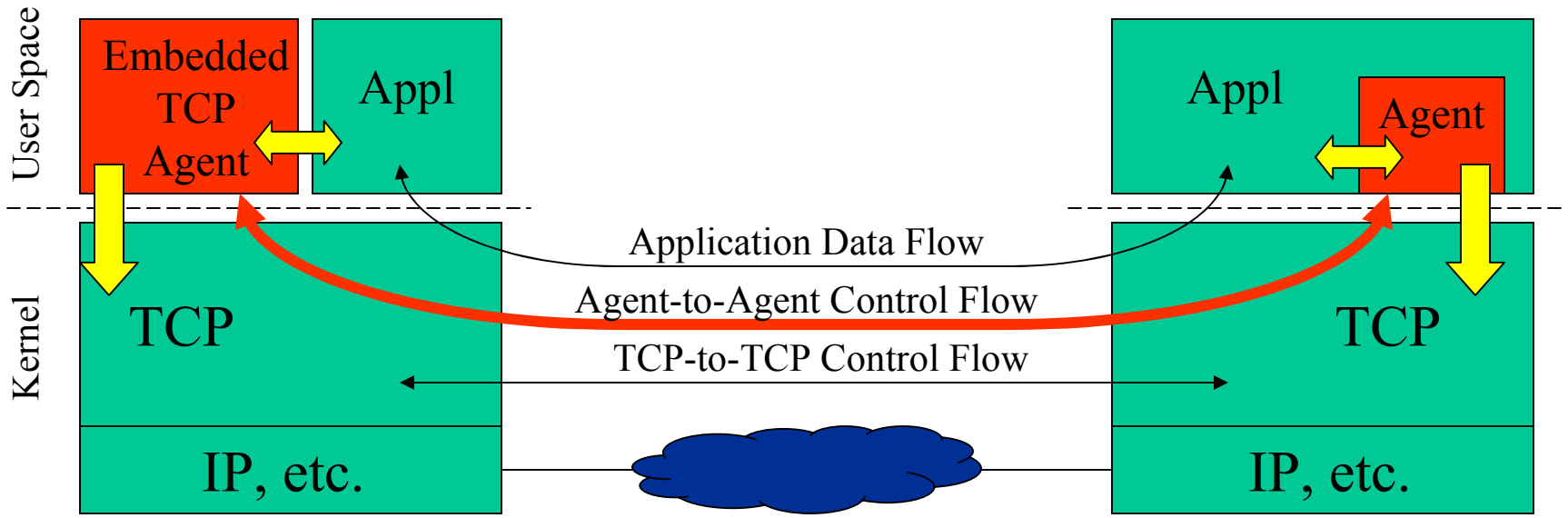
- Compatibility with SCPS-TP
  - Embedded transport agent concept and implementation could easily be ported to SCPS-TP
  - Resilient TCP connection extends SCPS-TP link-outage behaviors
    - Can easily be integrated into SCPS-TP specification, implementations

TCP Control Plane

- Provides an end-to-end control plane that will intelligently and dynamically modify the behavior of TCP
  - User-space “Embedded TCP Agents”
  - Agent-to-agent data stream
    - TCP-like transport protocol
  - TCP in-band, secondary data channel
    - Uses TCP options
  - TCP instrumentation

TCP Control Plane

Embedded TCP Agents



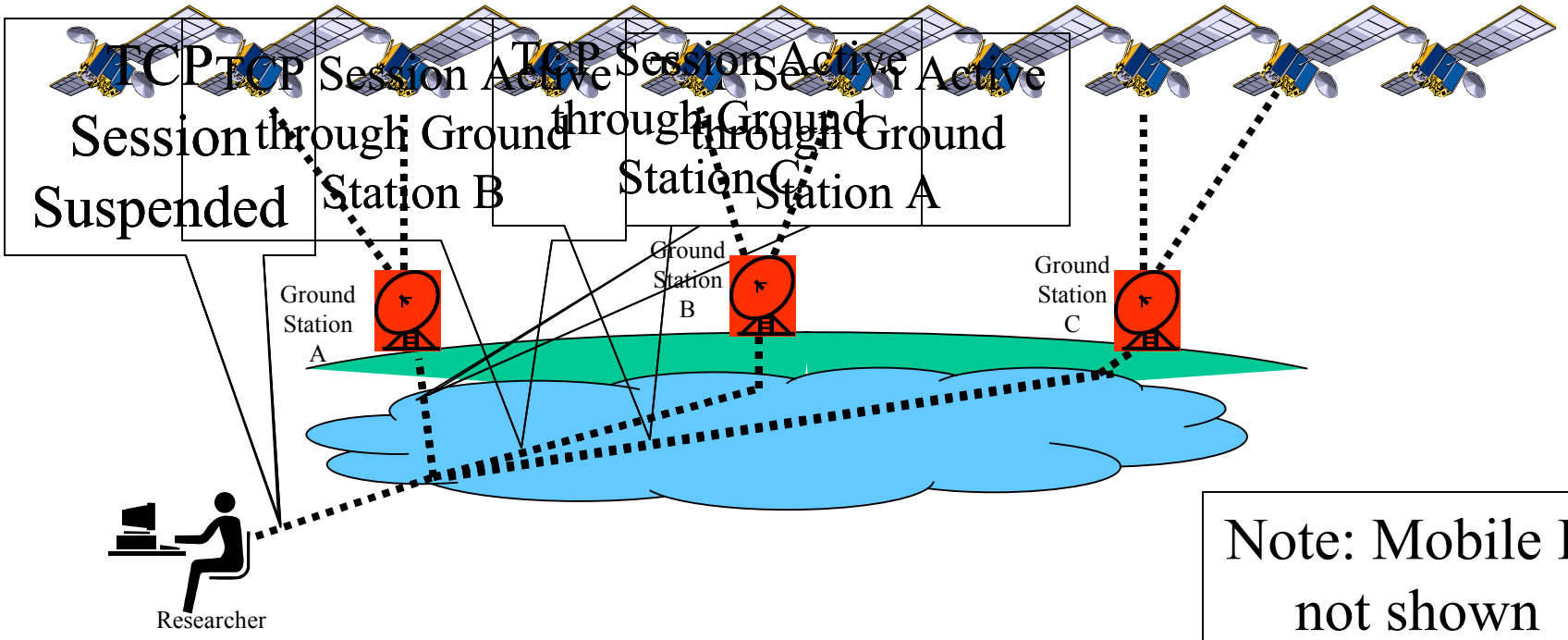
Resilient Connections

Resilient TCP connections will

- Maintain TCP connections across connectivity losses
  - Proactive response in anticipation of planned connectivity loss
  - Reactive response when (presumably temporary) connectivity loss detected

Resilient Connections

- Resilient TCP connections will maintain TCP connections across connectivity losses



Note: Mobile IP not shown

Resilient Connections

Resilient TCP connections should:

- Manage congestion window appropriately
- Free resources eventually
- Provide configuration controls

Interoperability

- Enhanced versions of TCP will maintain strict interoperability with existing TCP implementations
  - Use of new capabilities will be negotiated at run time between end points (TCP options)
  - Agent-to-agent communication will use TCP options
    - Minimize interaction with NATs, firewalls
  - An enhanced TCP will interoperate with an unmodified TCP

Interoperability

- Enhanced versions of TCP will maintain current end-to-end behaviors
  - No network infrastructure upgrades required
  - Avoid requirement of a proxy/gateway
  - Coexist with end-to-end encryption (IPSec)
  - Maintain end-to-end TCP semantics
    - End-to-end acknowledgements

Potential Applications

- Provide robust Internet-access-to-space service for investigators
  - Optimized performance provided by Embedded TCP Agents
  - Uninterrupted, end-to-end transport-layer communications provided by Persistent TCP Connections
- Automate satellite operations
- Enhance tactical or mobile communications
  - Future Combat Systems (FCS)

Current Status

- Funded by NASA/GRC under a Phase I SBIR contract
  - Draft protocol specification completed
  - Developing proof-of concept implementation
    - Using Alpine and Alpine4Linux user-space port of BSD TCP stack
  - Developing *ns-2* model
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Current Status

- Creating proof-of-concept demonstration
  - Demonstrate secondary data channel