



# High Availability TCP Through Resource Identification, Cognition, and Knowledge (HAT TRICK)

## Improving End to End TCP/IP Wide Area Network Performance

### Overview

TCP/IP networks are currently unable to meet the military's needs for effective, reliable communication between well-connected support sites (e.g., those in the continental United States) and forward military locations. SPARTA and Juniper Networks are producing an innovative, cost-effective solution that will dramatically improve the military's end-to-end communication by way of limited extensions on hosts and routers.

Assumptions about availability, reliability, and other transmission characteristics, which have become part and parcel in the design and implementation of TCP/IP stacks and the routing infrastructure, have improved overall performance and reliability in the commercial Internet. For military users communicating with forward locations, where these embedded assumptions are violated, TCP/IP's effectiveness is severely impacted.

### Solution

Our solution, HAT TRICK, will permit the military to make full use of its network – near the theoretical maximum – with discrete, backward-compatible changes at select points in the infrastructure. Our system will introduce frequent, fine-grained changes to routing and TCP/IP parameters based on continuous analysis and understanding of the network. It will do this without additional configuration and, save for the noticeable improvement in TCP/IP throughput and responsiveness, will be transparent to both applications and users.

HAT TRICK will provide sufficient information to

hosts to make intelligent TCP/IP parameter tuning and routing requests, instead of the current practice of blindly delivering packets to the network using parameters at one time believed to be optimal. It will augment TCP/IP stacks on participating hosts and augment a portion of the routing infrastructure with sufficient sensors, modeling, and optimization strategies to ensure that the military makes best use of its lossy, high-latency, and periodically unavailable links in forward areas.

### Approach

We have a history of addressing security research problems, including network availability, and producing solutions geared toward technology transfer through the development of standards and software prototypes licensed as open source. We work with multiple host operating systems and have expertise in kernel and TCP/IP stack internals.

Juniper Networks has developed an extensible, scalable routing architecture that has quickly penetrated the backbone ISP market, including selection for the Defense Information Systems Agency Global Information Grid Bandwidth Expansion (GIG-BE) program. Juniper's product line has continued to expand to include routers for both the network backbone and edge, all using a common binary image of the operating system and a common set of APIs that support the additional functionality required to field our solution in the infrastructure of the Internet with minimal impact on performance and cost.

SPARTA and Juniper Networks will provide a complete, end-to-end solution, HAT TRICK, for enhancing TCP/IP performance in military networks. Our solution will automatically learn network characteristics, continually optimize routing decisions, and improve TCP/IP stack tuning as knowledge of the network is refined.

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The characteristics of particular interest are those of non-conventional links (e.g., satellite, RF) close to forward-deployed forces. These *interesting* links violate many of the assumptions in the commercial Internet and end-to-end throughput suffers as a result.

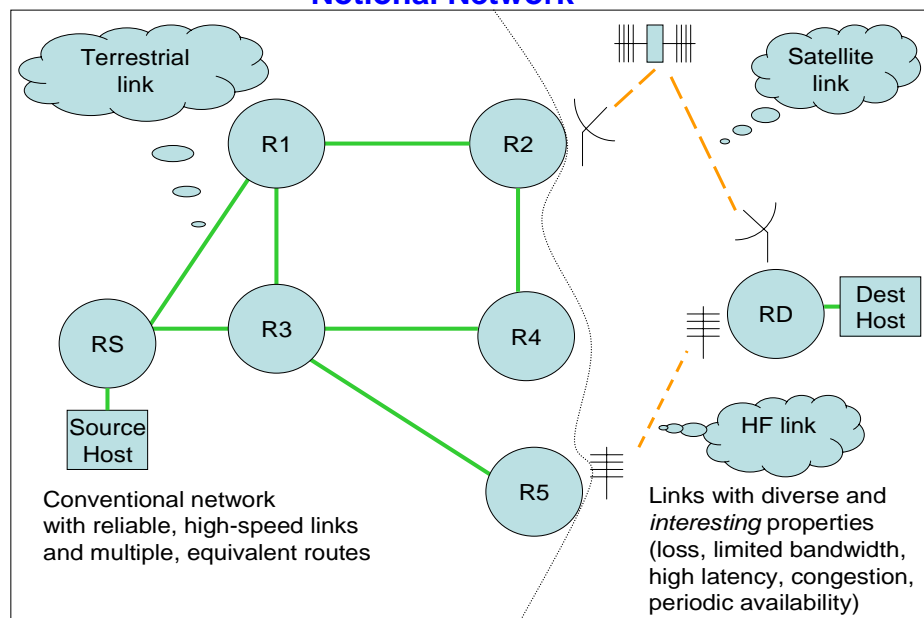
The three innovations that make up our HAT TRICK solution:

- Continuous, automatic monitoring and modeling of interesting links and the production of compact representations of the models that will be transmitted across the Internet and used for route selection and TCP/IP stack tuning. We will model links to identify their potential for various types of communication and adjust TCP/IP stack tuning parameters for maximum link utilization. We will take congestion, packet loss, Maximum Transmission Unit (MTU), uncorrectable bit error rate, throughput, latency, jitter, and periodicity into account. We will make measurements at the routers on either side of interesting links and use curve fitting techniques to model these properties and produce small yet accurate representations.
- Dynamic, end-to-end route discovery and monitoring of interesting links to ensure

optimal throughput and responsiveness for all applications using TCP. We will provide a simple extension to TCP/IP, a new ICMP query/response pair, to allow hosts to discover routes that use alternative interesting links at the near or far end of a connection in real time and additional SNMP MIBs for additional measurements for testing and analysis. We will use IP-in-IP encapsulation to tunnel packets to routers on either side of interesting links effectively changing the routing for end-to-end communication without requiring changes to the existing routing rules (BGP, OSPF, RIP, static routes) in the network backbone.

- Intelligent route selection and TCP/IP parameter tuning in response to the changing characteristics of interesting links to maximize throughput through reduction of packet loss and retransmission. We will use Bayesian network probability models to select optimal routes and TCP/IP tuning parameters based on the host's understanding of application data requirements and the model of each route's dominant link characteristics (those associated with the interesting link).

### Notional Network



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