Evaluation of Delay/Disruptive Tolerant Network (DTN) Solutions in Networks under Intentional Attack

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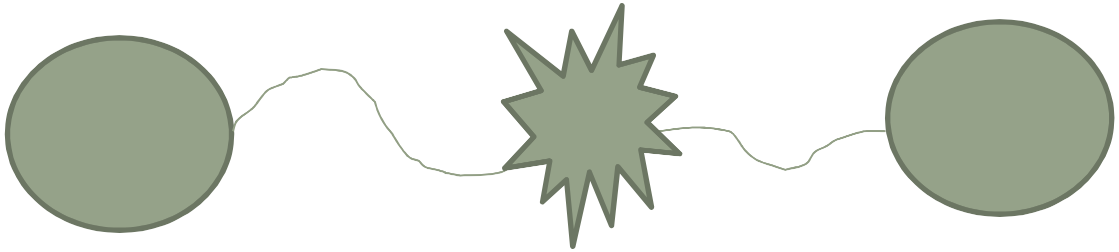
Outline

- Introduction to Delay/Disruptive Tolerant Network (DTN)
- *DTN as a Strategy for Information Assurance and Infrastructure Network Reliability*
- *Cyber Hyper-Domain*
- M&S for Cyber Battle Labs and CAX

DTN concept

- The DTN architecture embraces the concepts of occasionally-connected networks
- The basis for this architecture lies on **the Interplanetary Internet**
- Various operational environments, including those subject to **disruption and disconnection** and those with high-delay;
- Deep space is one specialized example
- **Other networks** to which DTN architecture applies

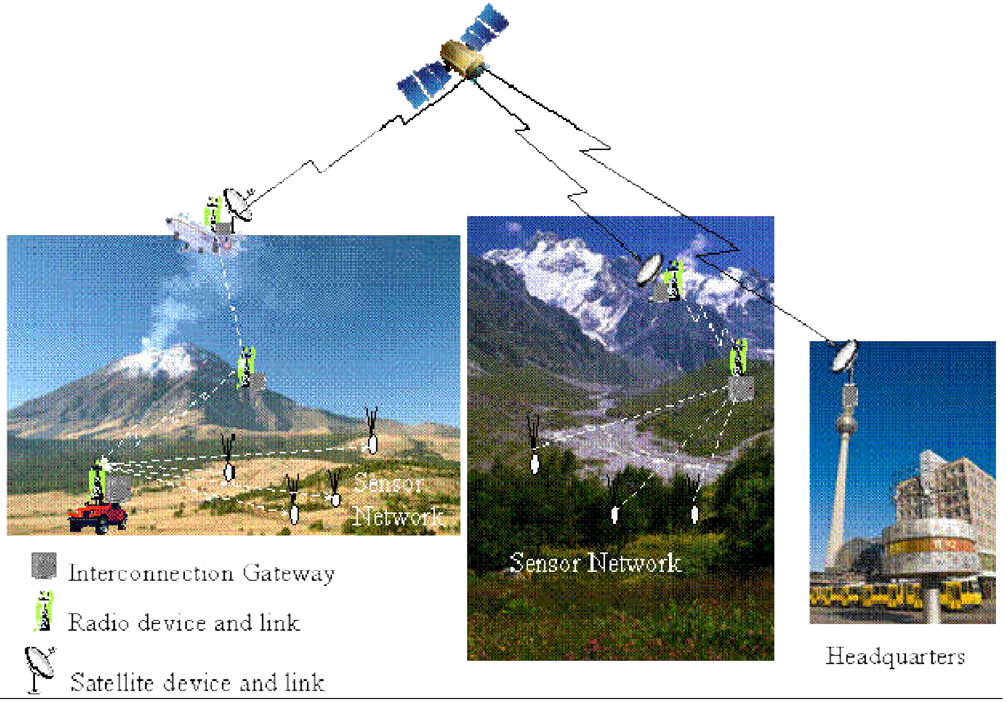
DTN concept



- DTN solution applies when End-to-end connection is : **not permanently guaranteed**; intentionally and not intentionally interrupted; operating with very large delays; operating intermittently

DTN application scenarios

- Emergency operations, interventions in hazardous areas,…

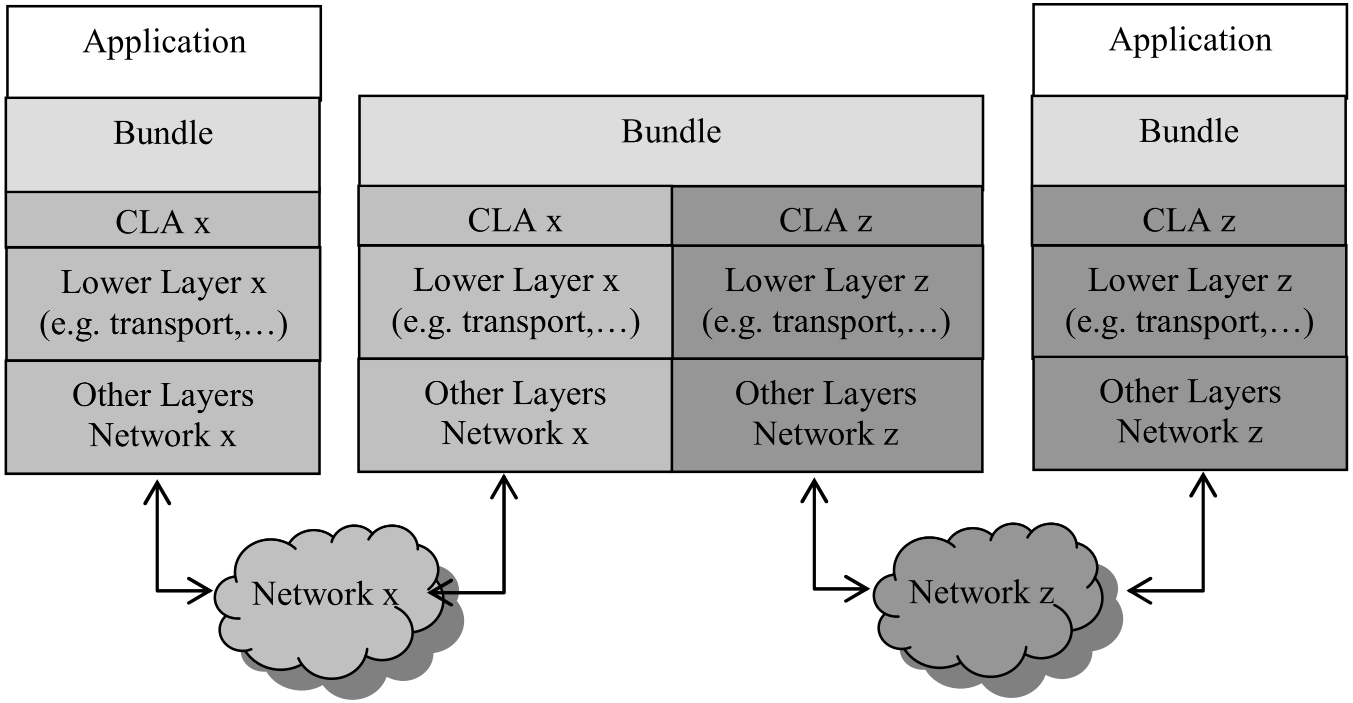


DTN Architecture Bundle Protocol

- *DTN architecture based on the **introduction of an overlay** above transport or other lower layer protocols*
- *The essential point is that in such an overlay, **delays and disruptions can be handled at each DTN 'hop'** in a path between sender and dest*
- *Nodes on the path can provide **storage***
- *The DTN architecture **does not require contemporaneous end-to-end connectivity***

DTN architecture Bundle protocol

- The basic unit of data in the Bundle Protocol is a “bundle” which is a message that carries application layer protocol data units
- The BP can interface with different lower layer (usually transport) protocols through “Convergence Layer Adapters”, (CLAs)



DTN as an overlay solution

- *DTN architecture is suited for acting as* ***overlay on top of a heterogeneous network***

- *By installing a Bundle Protocol Agent (BPA) on end-points and nodes at the border of homogeneous segments,* ***the end-to-end path can be divided into many DTN hops****.*

- *On* ***each DTN hop different CLAs can be used***

Information storage Int Nodes

- Another important difference between DTN and traditional **TCP/IP networking is related to information storage**

- In standard networks information is persistently stored only at end nodes

- This may not be the case in challenged networks. In DTN networks information is persistently (long-term) stored at intermediate DTN nodes

Information storage Int Nodes

- This feature differentiates the DTN architecture also from PEPs.
- In contrast, bundles can be stored at intermediate nodes for extended durations, and also be saved in persistent memory

DTN as Network Defense Strategy

- The new idea is to use **DTN to increment Infrastructrure Network Resilience**, mitigating the effects of an intention attack to network links/nodes;
- The attack is considered as a bandwidth reduction up until no bandwidth availability

Network Resilience and Cyber Defence

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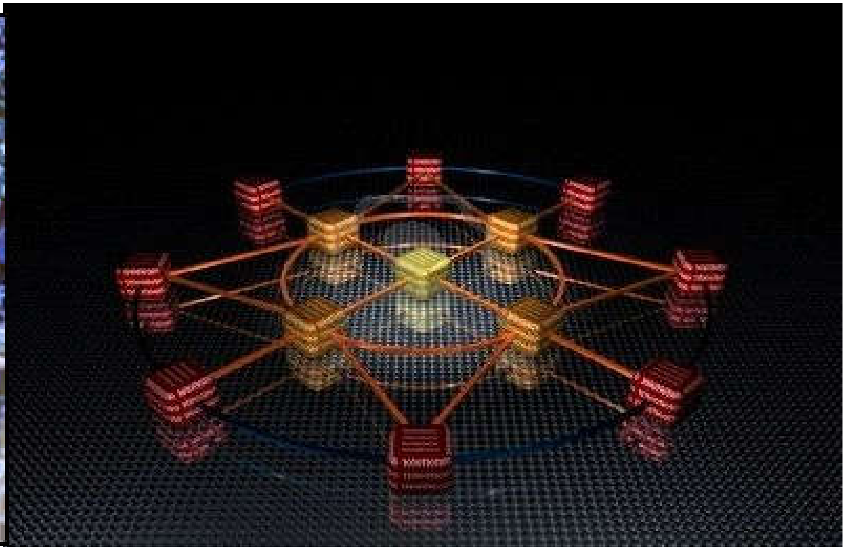
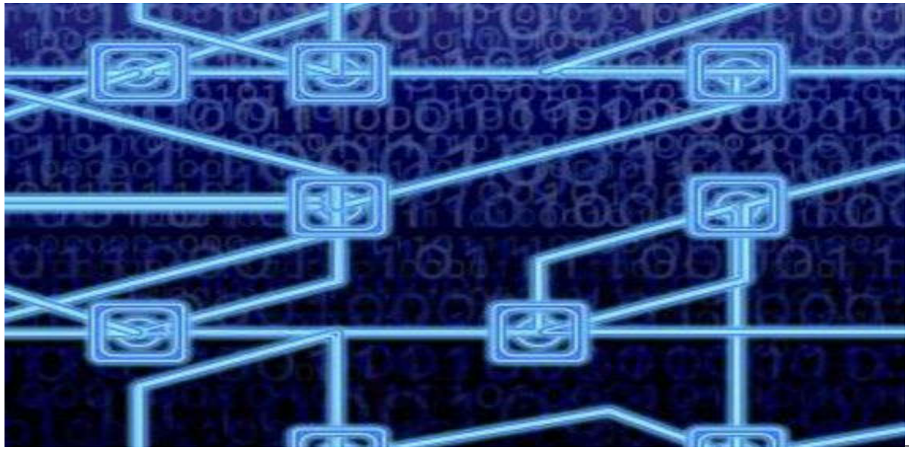
Network Resilience and Cyber Defence





Network Resilience to:

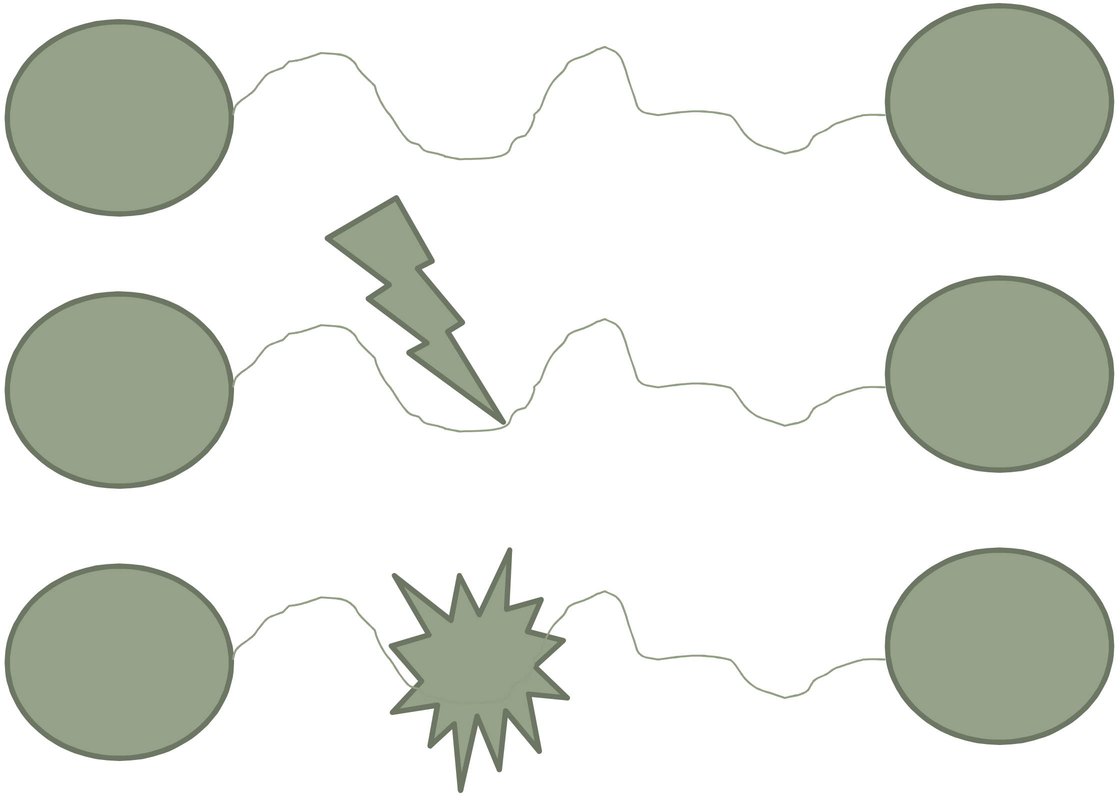
Protect Core Infrastructure

Assure Information Superiority in the Cyber Battle Field

- *Sithuation Awarness*
- *Common Operational Picture*

DTN as Network Defense Strategy

- Effect of the attack



Attack

Bandwidth

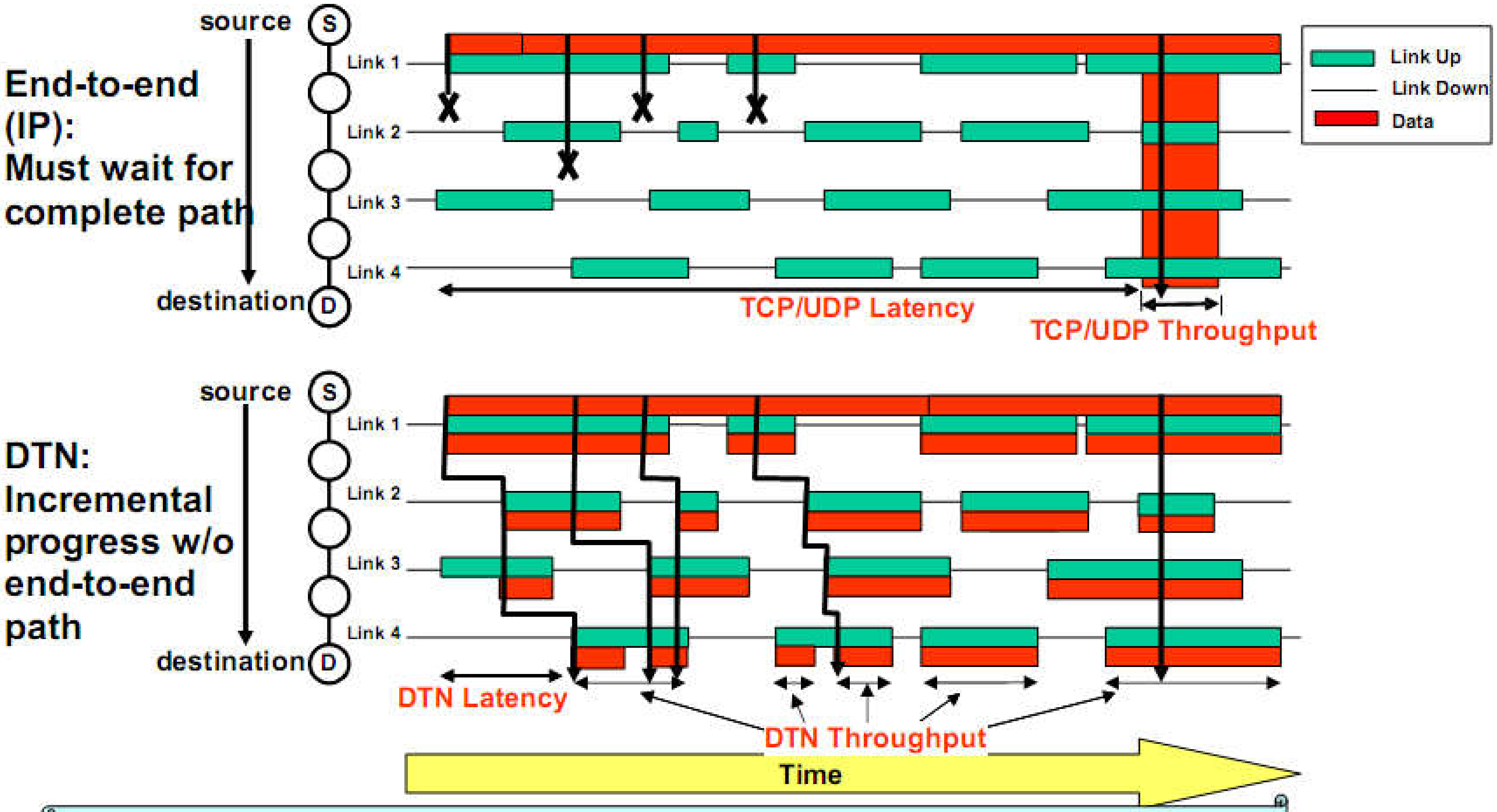
Cancellation

Link Disruption and
no service

DTN as Network Defense Strategy

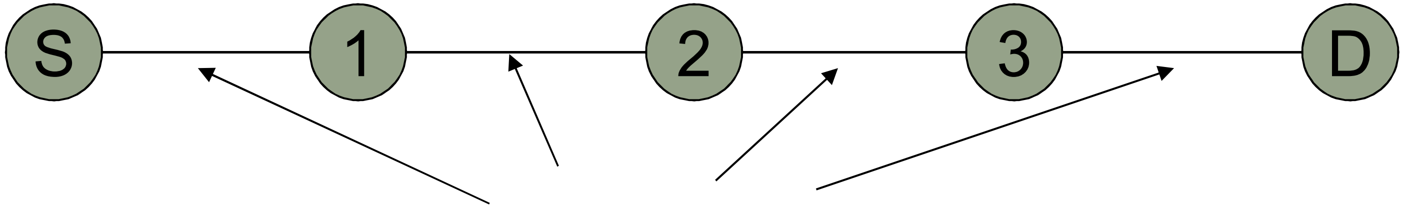
- If network nodes use the DTN architecture, can this help managing and mitigating the negative effect of the attack?
- Even if the hypothesis must be deeper verified, preliminary analysis support the idea

Preliminary results



DTN Can Reduce Delay and Increase Throughput

Very simple model



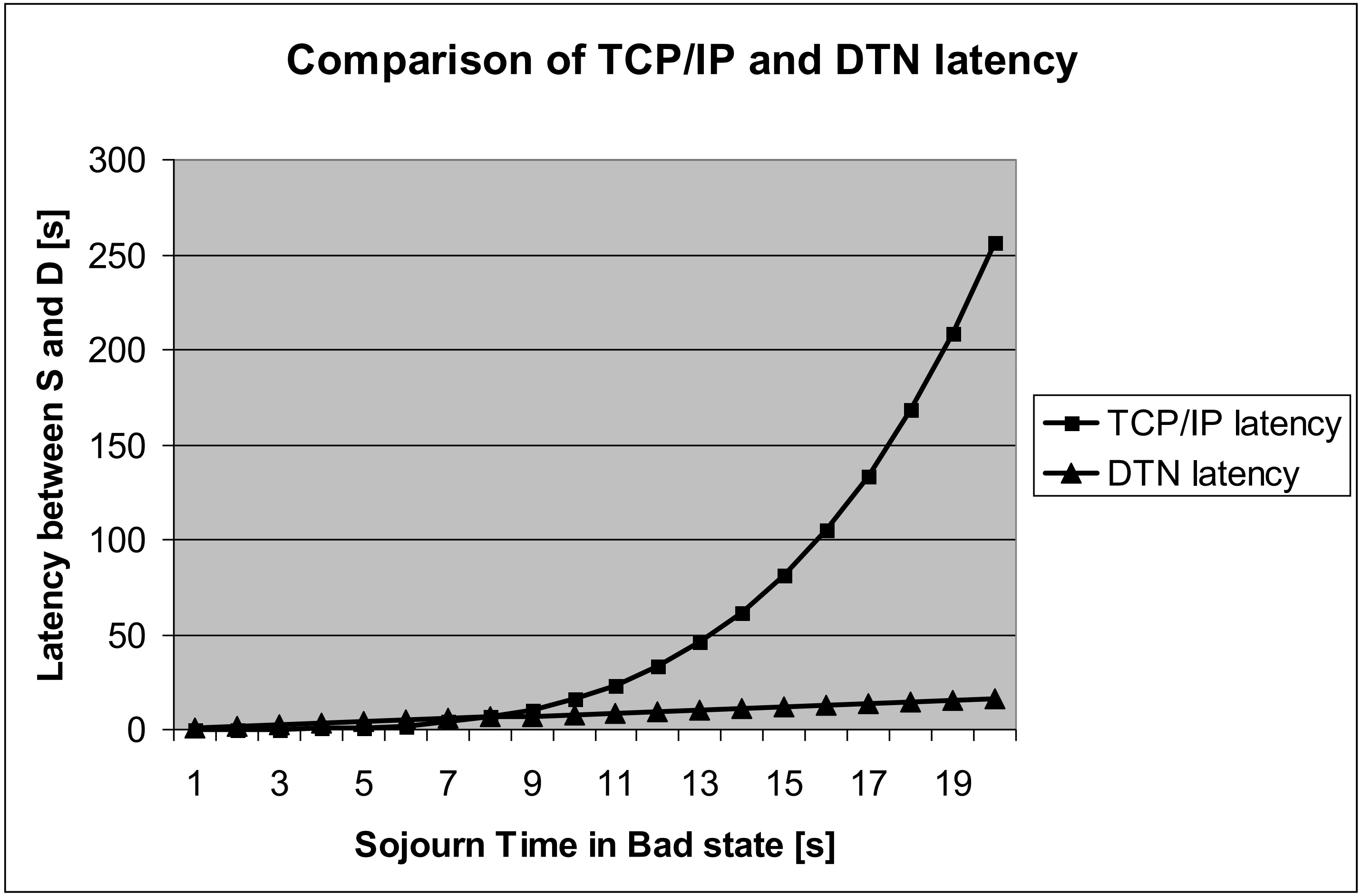
Links behavior modeled as 4 independent continuous Time Markov Chains

- π_G stationary probability of Good state (no interruption);
- π_B stationary probability of Bad state (interruption)
- T_B sojourn time in Bad state (exponentially distributed with parameter $\lambda_{B)}$
- $1/\lambda_B$ average sojourn time in Bad state
- T_x transmission time

Very simple model

- Single IP packet generated by S to D;
- TCP/UDP latency (must wait to complete a path)
  - $(\pi_B / \lambda_B)^4 + 4Tx$
- DTN latency
  - $4(\pi_B / \lambda_B) + 4Tx$

Very simple model



M&S Pillar

- More accurate Protocol Model;
- Protocol Behaviour Simulation - NS3 Based / OPNET Based
- Network Infrastracture Simulation – OPNET Based

Cyber Hyper-Domain

- DTN in Software Defined Networking Hypothesis: Cyber Hyper Dimensional or *Cyber Hyper-Domain*
  - *Free BSD Jials*
  - *Stanford Clean Slate Projects*

Cyber Hyper-Domain

- *Hyper-Dimentional* Cyber Domain (men-driven and/or autonomus cognitive processes to inter-dimension switch);
  - *Time*
  - *Space*
  - *Virtual Space*
  - *Autonomous Systems Domains /Topology / Routing Strategies and Protocols*
- Different NetworkTopology and Routing Strategy are separated in different Jails.

Cyber Defence CAX

- Cyber Hyper-Domain M&S
- Distributed Battle Labs Interconnection
- *Men and Autonomous Agents CAX in the simulated Cyber Hyper-Domain*

Cyber Defence CAX

- *Assure Information Superiority in the Cyber Hyper-Domain which directly translates into Power Superiority in the Battlefield*

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