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1. OVERVIEW OF THE PROJECT

Project SHIELD (HYPERION @ Imperial College) designs and evaluates an adaptive network architecture with enhanced functionality and resilience for battle space networks.

2. COGNITIVE PACKET NETWORK (CPN)

Self Aware Networks (SAN) is a proposal of QoS enabled networks with enhanced monitoring and self improvement capabilities that use adaptive packet routing protocols, such as **Cognitive Packet Network (CPN)** and address QoS by using adaptive techniques based on on-line measurements.

CPN [1] is a packet routing protocol which addresses QoS using adaptive techniques based on on-line measurements.

It provides QoS driven routing and performs Self-Improvement in a distributed manner, by learning from the experience of packets.

It makes use of 3 types of packets:

- ❖ **Smart packets (SP)** for discovery,
- ❖ Source routed **Dumb packets (DP)** to carry payload, and
- ❖ **Acknowledgements (ACK)** to bring back information that has been discovered by SPs which are used in nodes to train neural networks.

The AC decision of our proposed scheme consists of three stages. SPs associated with each flow, constantly explore the network and obtain routing decisions from network routers based on observed relevant QoS information.

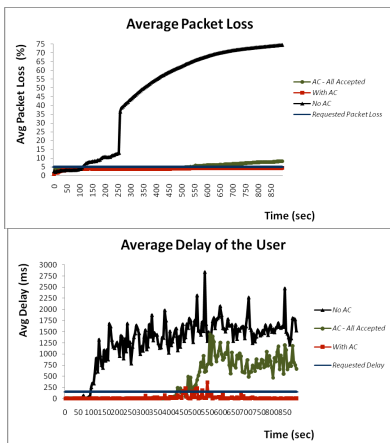
SPs learn from their own observations and from the experience of other packets to avoid congestion and to avoid being lost. SPs discover routes by using random neural networks [2] (RNN) with reinforcement learning (RL).

3. ADMISSION CONTROL IN CPN

The Multiple Criteria Admission Control (AC) scheme we propose is a centralised, measurement-based AC algorithm which consists of three stages:

- **Identification Stage**, where the network identifies the quality criteria that a new user has and translates them to QoS metrics, if that user is in no position to specify them himself.
- **Probing Stage**, where the AC estimates the impact of the new flow by probing the network.
- **Decision Stage**, where the AC searches whether there is a feasible path which can accommodate the new call by considering the impact of that new flow on the network without affecting the quality of formerly accepted flows. The decision is based on a novel algebra of QoS metrics, inspired by Warshall's algorithm.

4. EXPERIMENTAL RESULTS ON AC

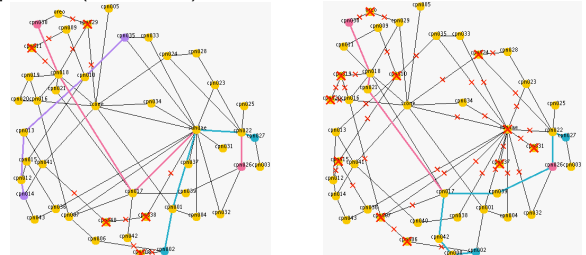


User Satisfaction (all QoS requirements are satisfied)

With AC	With AC enabled but users always accepted	Without AC
93.9%	49.4%	11.7%

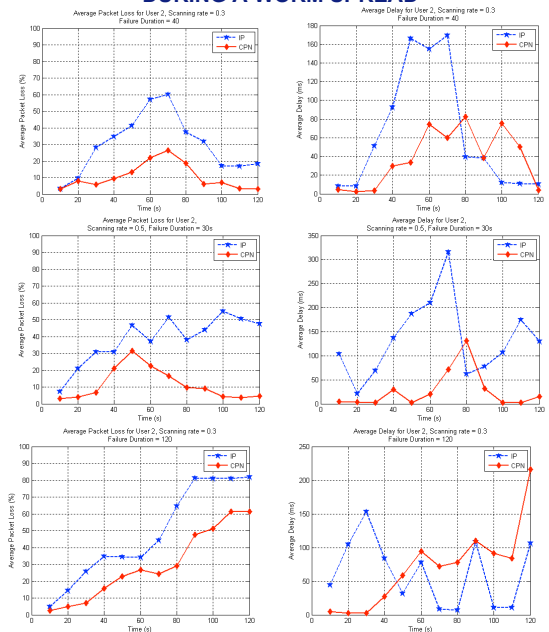
5. ADAPTIVE RESILIENCE OF CPN IN THE PRESENCE OF NETWORK WORMS

- Each node can be in one of the following states: *infected*, *immunised*, or *vulnerable*.
- The node failures are propagated as a computer worm, spreading randomly around the network and trying to infect it.
- The infections (failures) are spread according to two parameters: the *scanning rate* and the *failure duration*.
- *scanning rate*: the average number of machines scanned (infection attempt) per unit time, *failure duration*: the time an infected node will stay under failure. After that time the node is patched (immunised).



Our 46-node testbed at the beginning and during the spread of the worm

6. EXPERIMENTAL RESULTS ON NETWORK RELIABILITY DURING A WORM SPREAD



PUBLICATIONS

- G. Sakellari and E. Gelenbe, *Adaptive Resilience of the Cognitive Packet Network in the presence of Network Worms*, Submitted in NATO Symposium on C3I for Crisis, Emergency and Consequence Management, Bucharest, Romania, May 2009.
- G. Sakellari and E. Gelenbe, *Network Reliability through Autonomous Adaptation*, submitted in ICAC 2009, Barcelona, Spain, June 2009.
- G. Sakellari, *The Cognitive Packet Network: A Survey*, Accepted in the Special Issue on Random Neural Networks, The Computer Journal, 2008.
- G. Sakellari and E. Gelenbe, *A Multiple Criteria, Measurement-based Admission Control mechanism for Self-Aware Networks*. CHINACOM'08, Aug 2008. BEST PAPER AWARD.
- G. Sakellari, L. Hey, and E. Gelenbe. *Adaptability and failure resilience of the cognitive packet network*. Demo Session of the INFOCOM'08, Apr 2008.
- E. Gelenbe, G. Sakellari, and M. D' Arienzo. *Admission of QoS Aware Users in a Smart Network*. ACM Transactions on Autonomous and Adaptive Systems, 3(1), Mar 2008.
- G. Sakellari, E. Gelenbe, and M. D' Arienzo. *Admission of Packet Flows in a Self-Aware Network*. BIONETWORKS 2007 Workshop, MASS'07, Oct 2007.
- E. Gelenbe, G. Sakellari, and M. D' Arienzo. *Controlling Access to Preserve QoS in a Self-Aware Network*. SASO'07, pages 205–213, July 2007.
- G. Sakellari, M. D' Arienzo, and E. Gelenbe. *Admission Control in Self Aware Networks*. GLOBECOM'06, San Francisco, November 2006.