A Framework to Quantify Network Resilience

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wiki.ittc.ku.edu/resilinets/Metrics_and_Modeling

Introduction

- Network resilience
  - critical to meet service requirements
  - metrics needed to measure & evaluate (ResiliNets P4)
  - inherently complex problem, needs tractable solution
- Approach
  - characterise networks using orthogonal dimensions:
    - operational state (N) and service state (P)
    - quantified as tuple of metrics objective functions (N, P)
  - model challenges as perturbations in operational state
  - evaluate resilience as transitions in state space
    - for $S_1 \rightarrow S_2$ ordering of states $S_1 < S_2$ indicates improvement

Resilience State Space

- State space divided into 3×3 regions
  - boundaries defined by service requirements
  - piece-wise axes
  - $D^3R^2$ strategy trajectory
    - e.g. defend: $S_0 \rightarrow S_{1,\neq 0}$
    - e.g. remediate: $S_1 < S_c$
- Objective functions (N, P)
  - derived from parameter set
  - linear or logical combinations
- Resilience measured by
  - trajectory through state space
  - aggregate metric: $R = 1 - \text{norm. area under trajectory}$

Multilevel Framework

- Resilience at an arbitrary layer boundary
  - isolates resilience at any level
  - quantifies the impact of
    - challenges on the service
    - resilience mechanisms
- State space mappings
  - service parameters become operations at layer above
    $N_{i+1,j+1} = P_{i,j}$
  - resilience as seen by application at $L_{47}$ boundary
  - bottom-up approach

Simulation Results

- Multilevel resilience of ISP-level networks
  - resilience of AT&T, Sprint, GÉANT2 topologies
  - resilience of multi-path mechanism using $k$ paths

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