Distributed monitoring of IP-availability

Jorma Kilpi, VTT

February 8, 2008

Availability vs. IP-Availability

In this presentation

- Availability is *a cumulative*[a] concept, it includes layers 1 and 2.
- IP-Availability is *a conditional* concept, conditional that the layers 1 and 2 are available.

Depending on the context the IP-Availability may contain

- connectivity, packet loss ratio (PLR), DHCP and DNS performance,. . .

[a]The availability of layers 1 and 2 is a necessary but not a sufficient condition for the availability of layer 3.

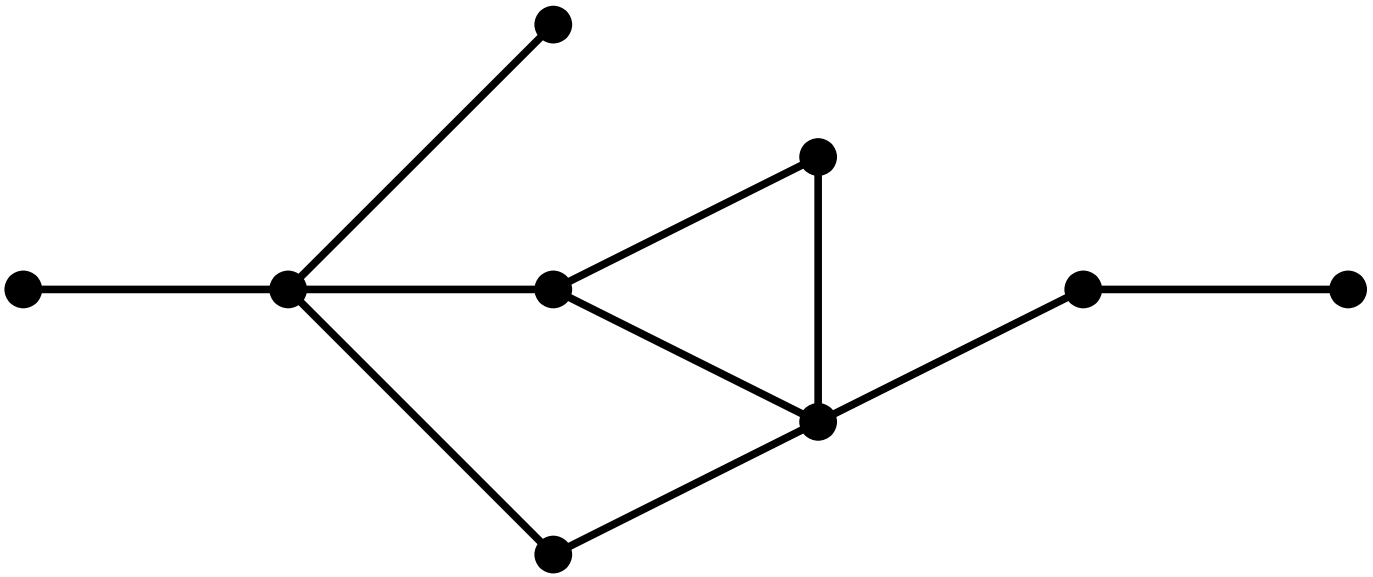

Figure 1: *Sites connected by a packet switched IP-network.*

Multiple paths (routing) affect to the connectivity and PLR.

Monitoring of Availability and IP-Availability

Monitoring of availability and IP-availability is meaningful if there is some reason to set a target objective for the availability of an IP network segment:

- in order to quarantee end-to-end (E2E) Quality of Service (QoS).
- often there is a Service Level Agreement (SLA) between the IP network operator and the end-to-end service provider.

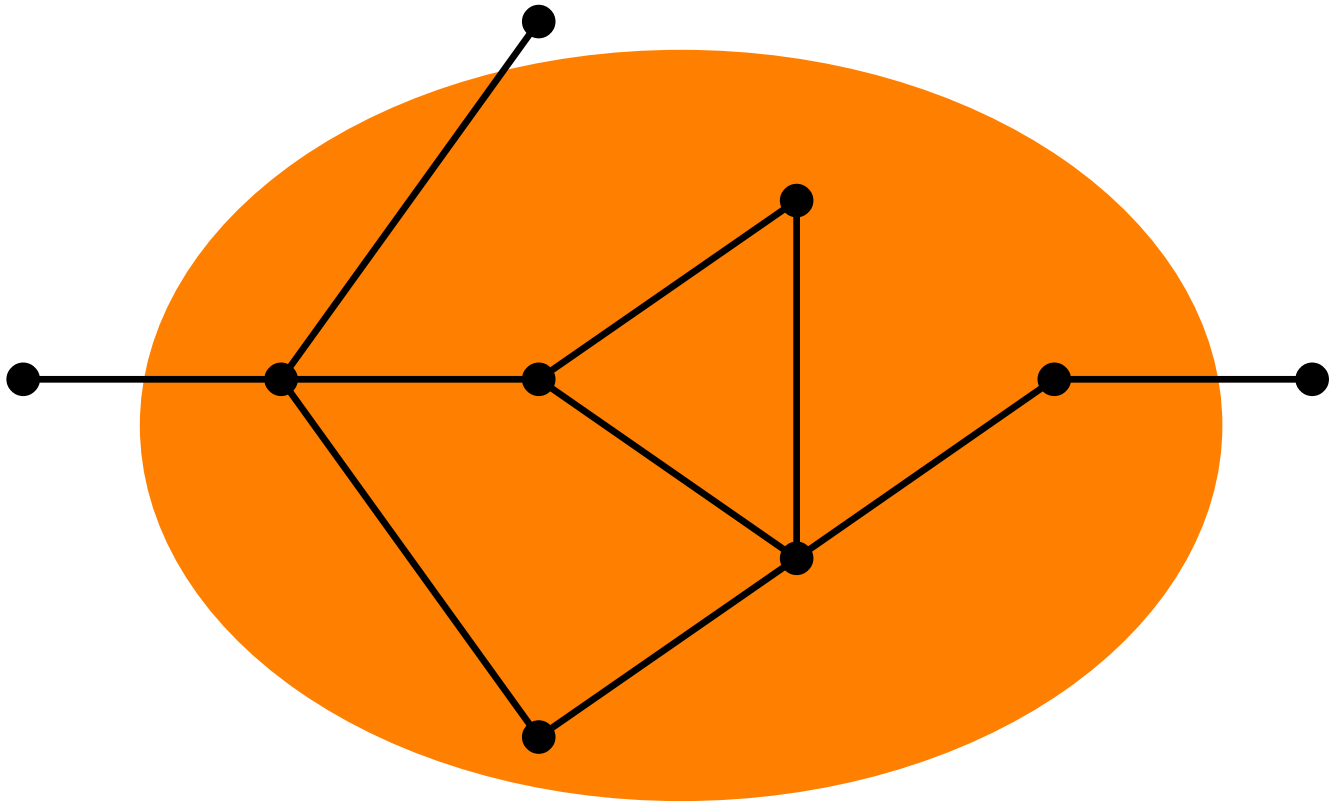

Figure 2: *Transport operator connects company sites: leased transport service.*

Both the operator and the company perform active probing.

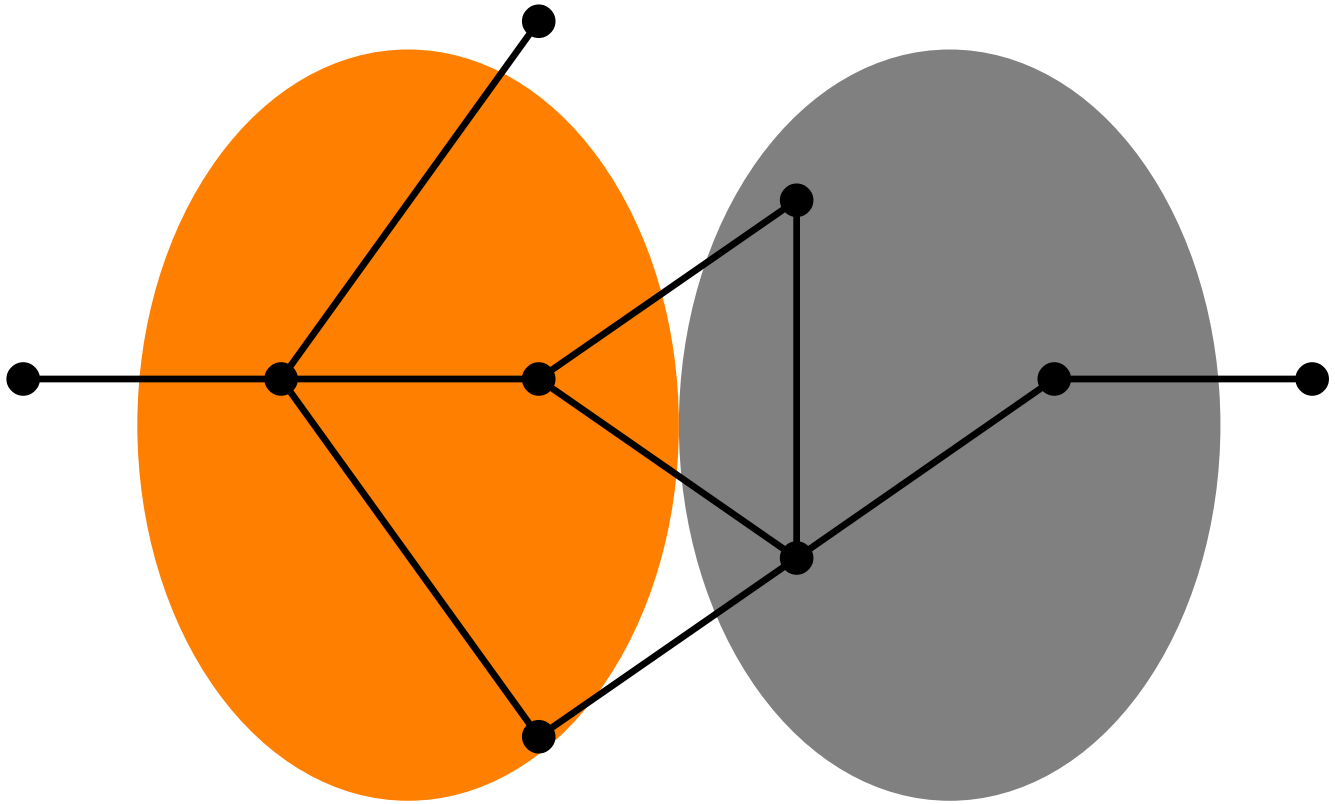

Figure 3: *End-to-end connectivity through multiple networks of different operators.*

Availability is related to time

What kind of objectives for availability can exist in a packet switched IP-network?

Availability	Maximum outage times		
	Daily	Monthly	Yearly
99%	864 s	432 min	88 h
99.9%	86.4 s	43 min	8h
99.99%	8.6 s	4 min 24 s	53 min
99.999%	0.9 s	26 s	5 min

Table 1: *Availability percentages and the corresponding outage times.*

From this table one can conclude that if the target objective to availability is set to 99.999%, then the time granularity of the monitoring must be finer than 0.9 s.

- While meaningful in the physical and link layers, is this meaningful in IP-layer?
- Especially since the IP-layer monitoring very much relies on active measurements.

Problems in relating IP-availability to time periods

Active probing has many restrictions:

- intrusiveness must be minimized
- sending schedules: random, periodic, bursty,. . .
- some level of synchronization required: loss requires rough knowledge of delay
- sequence numbers: it should be possible for a receiver to decide when a packet is lost
- active probes should be indistinguishable from ordinary traffic
- authorization: to restrict the active probing traffic

Active measurements are likely to be hierarchical and centrally controlled.

Connectivity and Packet Loss Ratio (PLR) of IETF

Connectivity	RFC 2678	IP-availability
Packet Loss Ratio (PLR)	RFC 2680	IP-availability, E2E QoS
One-Way Delay (OWD)	RFC 2679	E2E QoS
Packet Re-Ordering	RFC 4737	E2E QoS
Packet Loss Pattern	RFC 3357	E2E QoS
Round-Trip Delay	RFC 2681	E2E QoS
Packet Delay Variation (PDV)	RFC 3393	E2E QoS
Inter-Packet Delay Variation (IPDV)	RFC 3393	E2E QoS

Table 2: *The metrics defined by the IP Performance Monitoring Group of IETF.*

RFC 2678: IPPM Metrics for Measuring Connectivity

- *Instantaneous One-way Connectivity at time* T means $src \xrightarrow{P} dst$ **succesfully** at time T.
- *One-way Connectivity at the time interval* $[T, T + dT]$ if instantaneous connectivity at time T', $T \leq T' \leq T + dT$. That is, $src \xrightarrow{P} dst$ succesfully at some time T', $T \leq T' \leq T + dT$.
- *Two-way connectivity*: $src \xrightarrow{P} dst$ succesfully at some time T', $T \leq T' \leq T + dT$ and $dst \xrightarrow{P} src$ succesfully at some time T'', $T \leq T'' \leq T + dT$. (It is not required that $T' < T''$.)
- *Two-way temporal connectivity*: $src \xrightarrow{P} dst$ succesfully at some time T_1, **with delay** dT_1, $T \leq T_1 \leq T_1 + dT_1 \leq T + dT$ and $dst \xrightarrow{P} src$ succesfully at some time T_2, **with delay** dT_2, $T \leq T_2 \leq T_2 + dT_2 \leq T + dT$ **and** $T_1 + dT_1 \leq T_2$.

RFC 2678: Methodology for Measuring Connectivity

Algorithm: Input parameters are addresses A_1 and A_2, packet types P_1 and P_2, N the number of packets to be send as probes and W the *waiting time*[a].

1. Compute N sending times that are randomly, uniformly distributed over $[T + dT - W]$.
2. At each sending time, transmit a well formed packet of type P_1 from A_1 to A_2.
3. Inspect incoming network traffic to determine if a successful reply (packet of type P_2 from A_2 to A_1) is received.
4. If any successful reply is received, the value of the measurement is "True". If no successful replies are received by time $T + dT$, the value of the measurement is "False".

Recommended values of RFC 2678: $dT = 60s$, $W = 10s$ and $N = 20$ packets. That is, a PLR $\frac{1}{N} * 100\% = 95\%$ is allowed! **Note:** A TCP SYN-ACK coming back from the destination indicates temporal connectivity while ICMP "host unreachable" or "network unreachable" suggests a lack of temporal connectivity.

[a] To avoid exact knowledge of delays dT_1 and dT_2

ITU-T Recommendation Y.1540: IP service availability

The Y.1540 defines an unidirectional concept of *IP service availability* along an E2E path by setting an outage criteria as $PLR > c_1$.

- Threshold values like $c_1 = 0.75$ and $0.03 \leq c_1 \leq 0.2$ are suggested, depending on the traffic class.
- For active probing Y.1540 suggests $M = 1000$ packets during an interval of $T = 300$ seconds (5 min). Then the probing intensity is $\frac{M}{T} = 3.3$ PPS (packets per second)

This definition allows to divide time into contiguous slots of length T and with this granularity to bind this definition of IP service availability to time intervals.

- So coarse granularity will not allow to say more than about 99.9% of time.
- It is quite possible that the correlation with the user experience is low because users send packet bursts with much higher intensity.

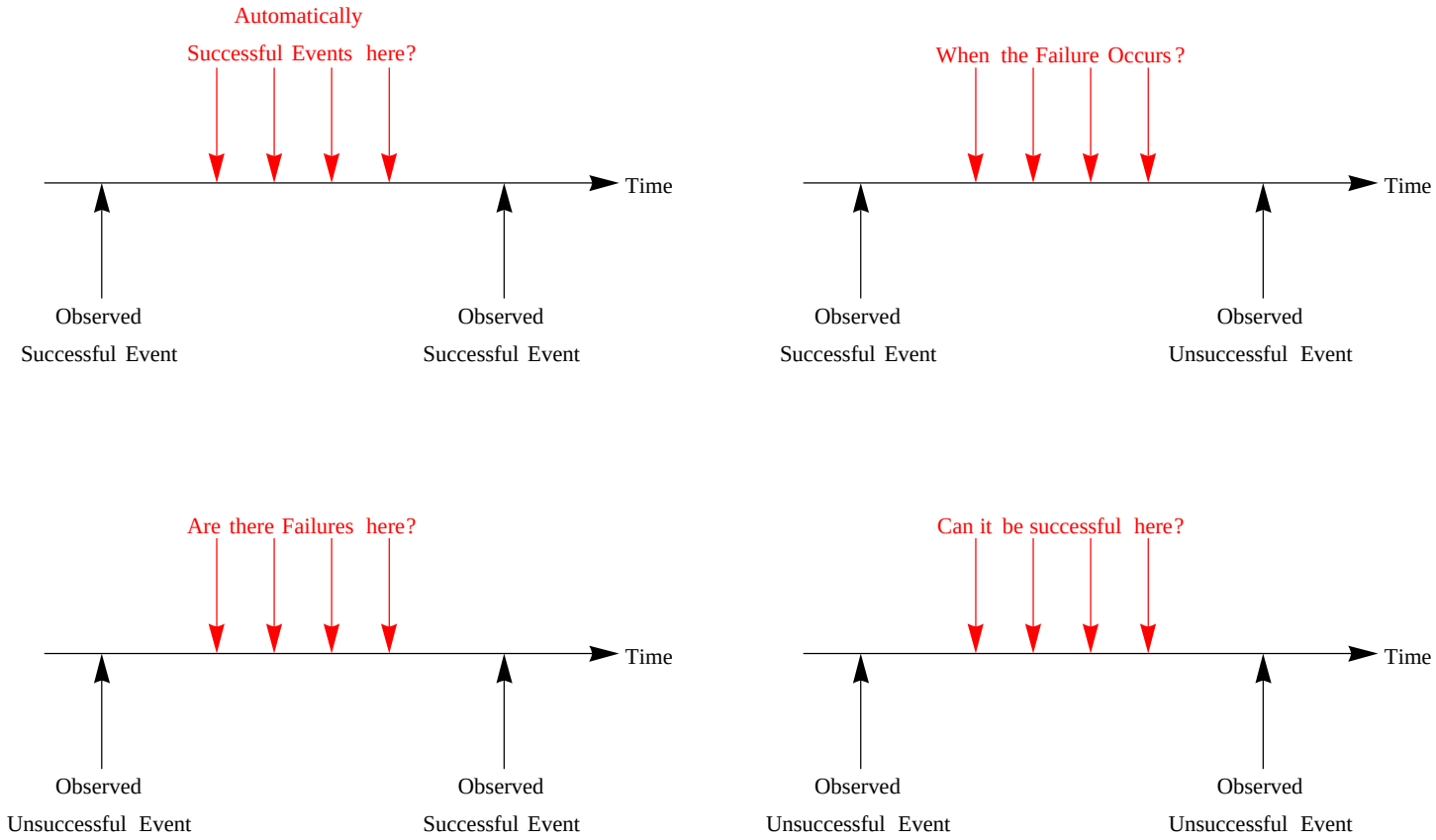

Figure 4: *Problems in making statistical inference about continuous time intervals from IP-event based observations.*

Summary and conclusions

- Active probing is centrally controlled and inevitably of coarse granularity.
  - The amount of active probing traffic is restricted.
  - Inference about time intervals is not easy.
- We propose to use event based definitions of IP-availability in SLA like:

  "Whenever layers 1 and 2 are available"
  - $PLR \leq 10^{-k} \times 100\%$ under any path through the network.
  - Connectivity: for example $\frac{\#SYN-ACK}{\#SYN} \geq 1 - 10^{-k}$ with any feasible src-dst pair.
  - Similar criteria for DNS and/or DHCP performance.
- Event based definitions can be monitored both actively and passively and the measurement results have a direct interpretation.
  - Distributed and even passive monitoring of IP-availability is possible by simple counters.