Measurement of Jitter over time

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Overview

- Voice and data transmissions in low bandwidth and high latency networks (i.e., typical Pacific Islands)

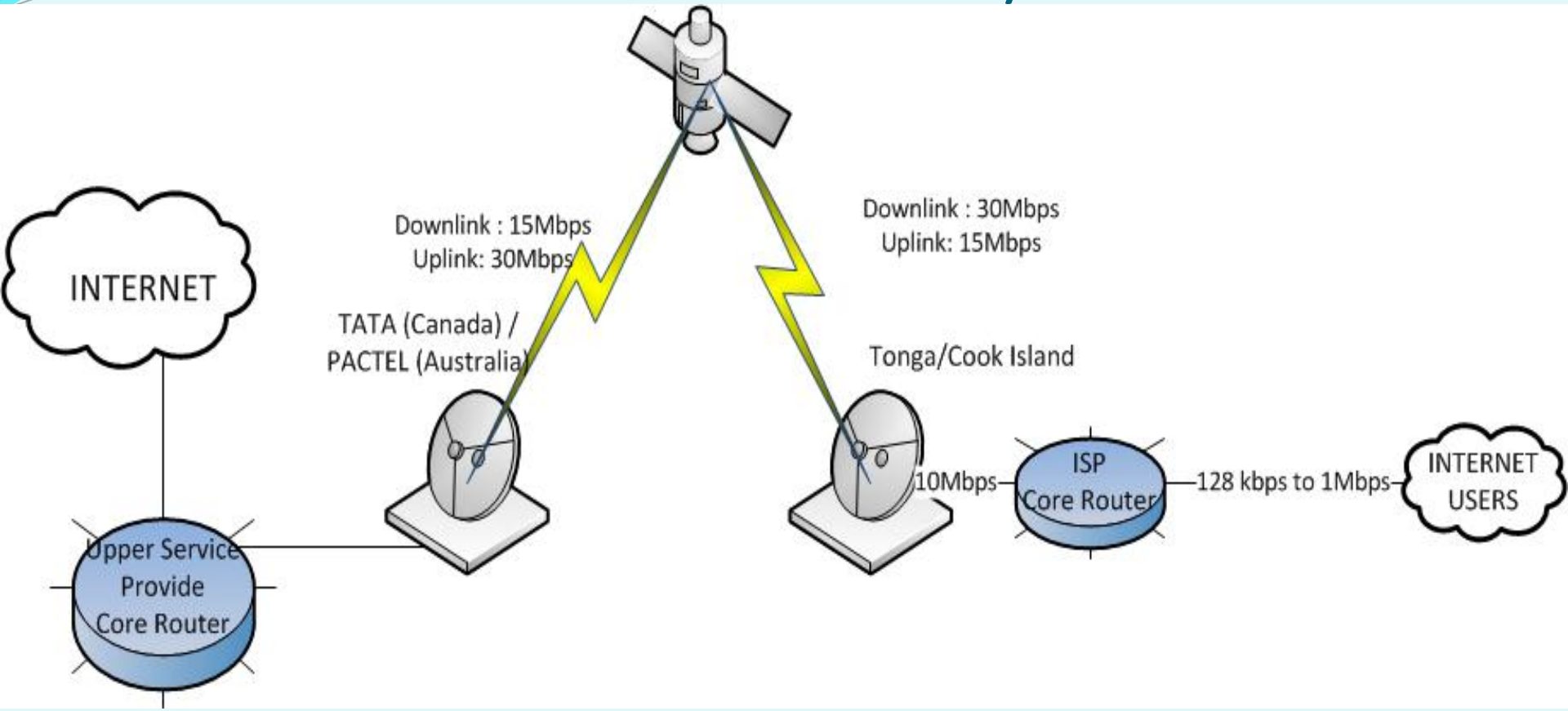
- Measurement of jitter for voice and data transmission in high latency and low bandwidth networks

Pacific Island Countries (PICs)

- Region spread across 33 million square kilometres of ocean.
- Home to 22 countries. Consist of 1118 inhabited islands, many barely above sea level.
- Each country has less than 25% of population with access to Internet. Internet available in work places, educational institutions and public facilities.

Source: Ministry of Lands in Tonga

International Connectivity in PICs



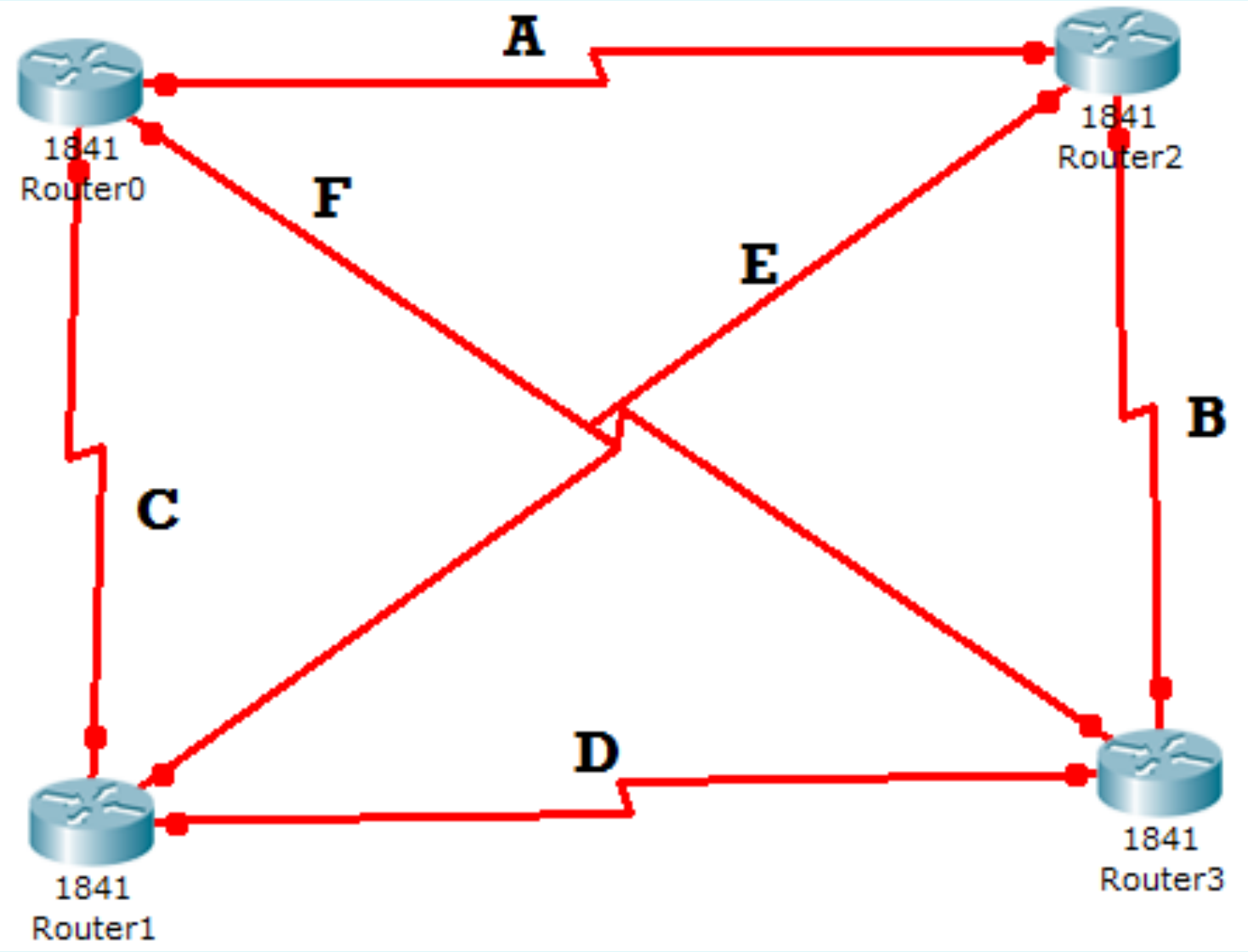
- Internet connectivity is possible with high latency satellite links to TNZI in NZ, TATA in Canada, PACTEL in Australia.
- Maximum downlink less than 30Mbps; uplink of approximately 15Mbps for whole country. Customers purchase bandwidth from 56Kbps to 2Mbps.
- Fibre optic submarine cables only in few places such as New Caledonia,

Last Mile Internet Connectivity in Pacific Island Countries

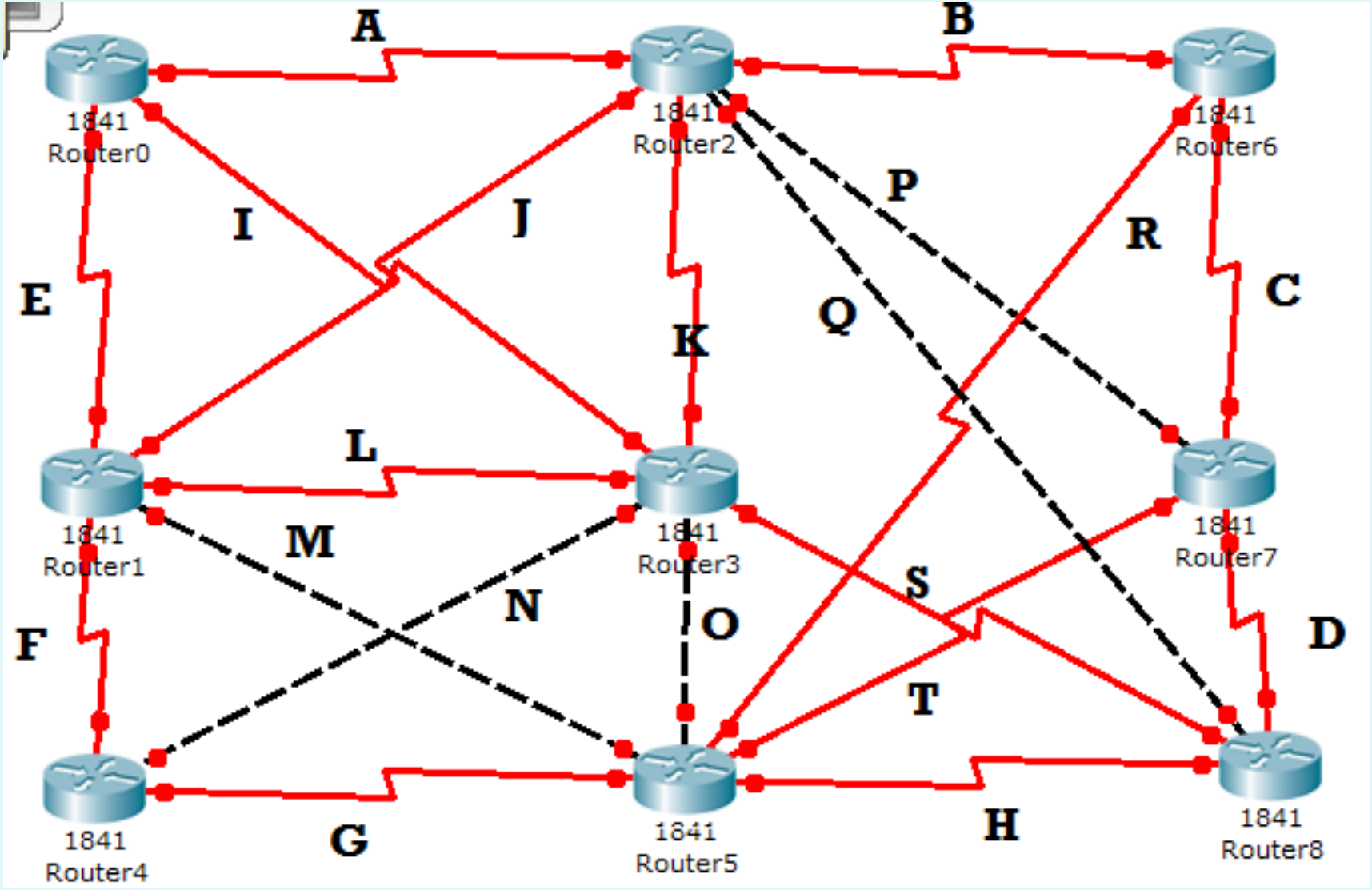
- Old routers used to connect to Internet
- Updated your firmware lately?
- Old computers without antivirus or security updates
- Poorly maintained phone cables used to connect customers, with few ADSL subscribers

Source: Ministry of Lands - remote solar centre

Packets Transmissions



Packet Transmissions



So…

- Old overloaded infrastructure communicates over links with little bandwidth and a lot of unwanted traffic.
  - Long router queues/high packet loss
  - Possible multipath on international links
- This means: packets that we transmit at regular intervals (such as in a VoIP stream) don't necessarily arrive at regular intervals – or at all
- This means VoIP and other real-time protocols don't work that well in the Pacific
- Can we measure this objectively?

Our Beacon Network

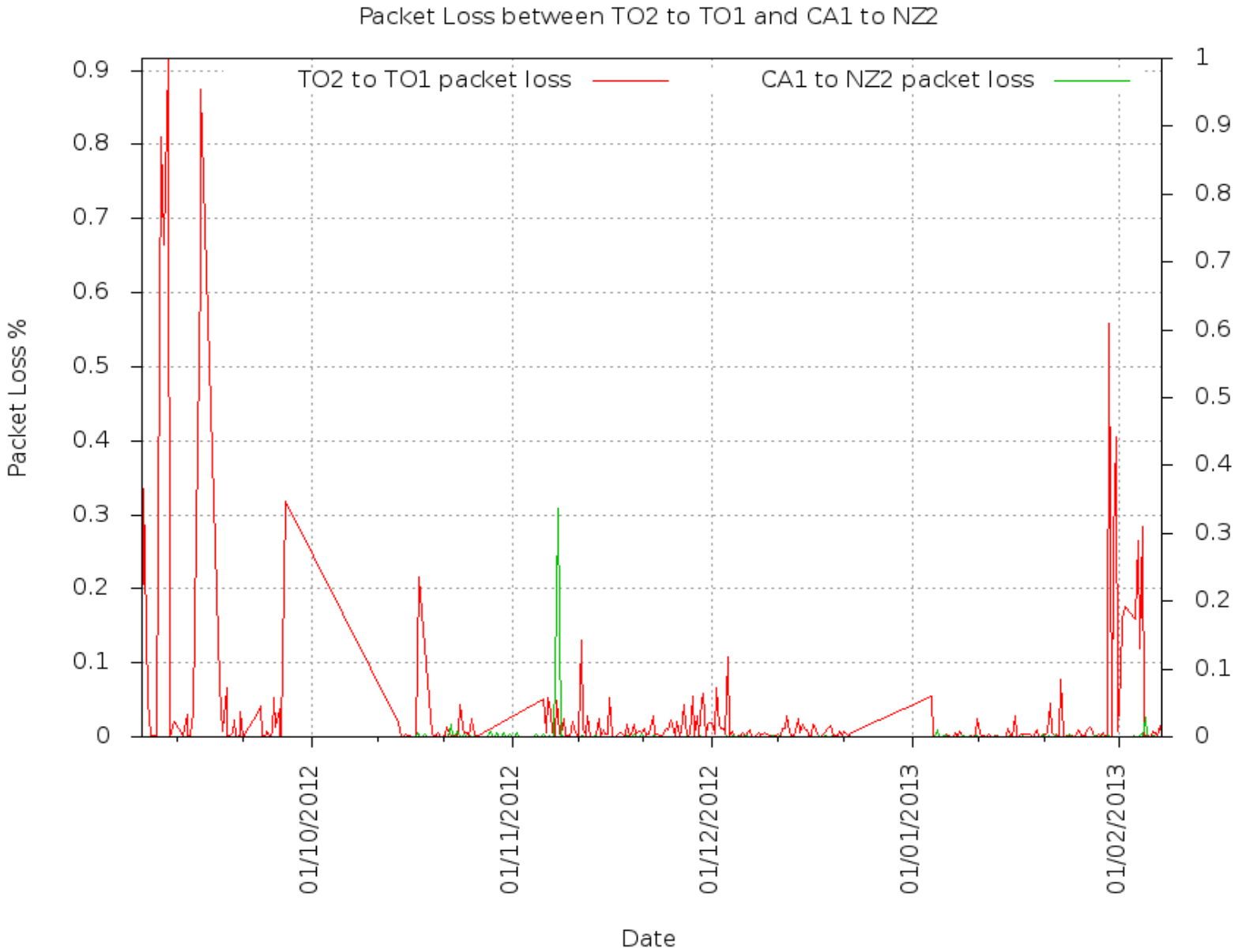
URL: https://130.216.5.147/

Username: csusers Password: cs2013

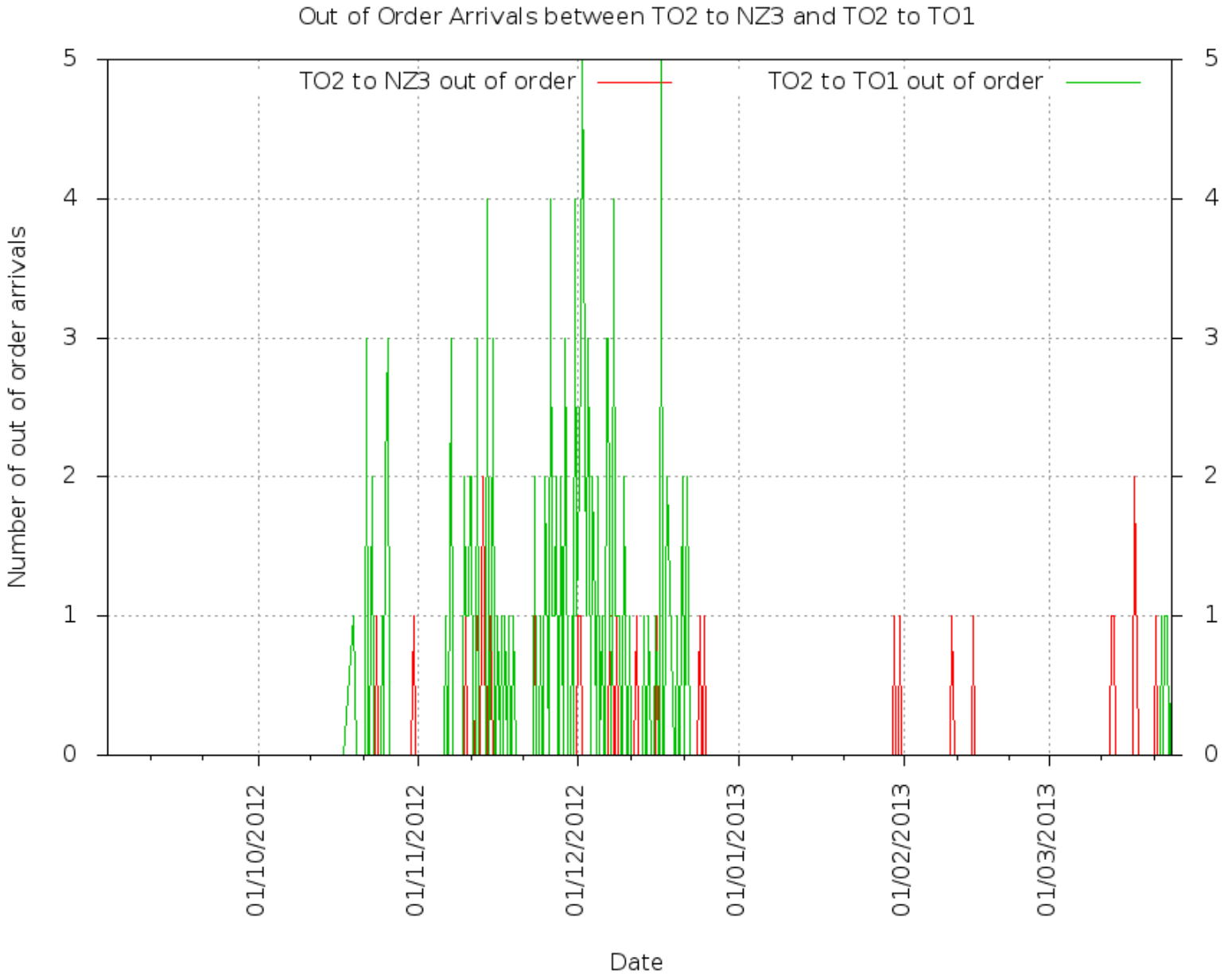
What the Beacons do

- Work in pairs to exchange synthesised traffic
  - UDP: VoIP-like stream of numbered and timestamped packets
  - TCP: VoIP-like constant data rate stream
  - TCP: Download-like maximum data rate stream
- Log packet/data arrival time plus TTL at receiver
- Also log transmit queue time and dequeue time
- Logs retrieved to central repository for analysis and archiving

Example – Packet Loss



Example: Out-of-order arrivals



Jitter

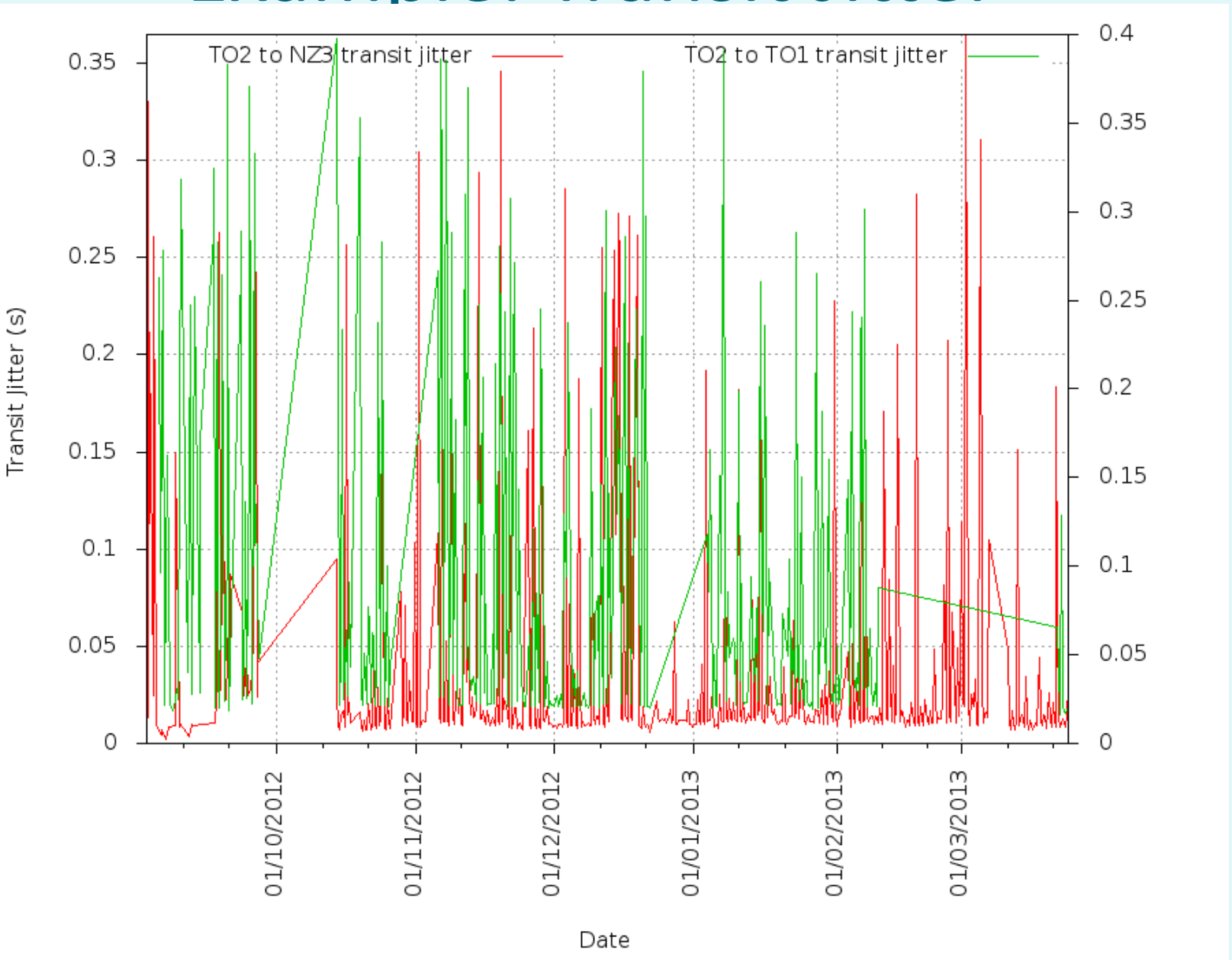
- Jitter is the variation in packet travel times and / or packet arrival times

- Different definitions exist

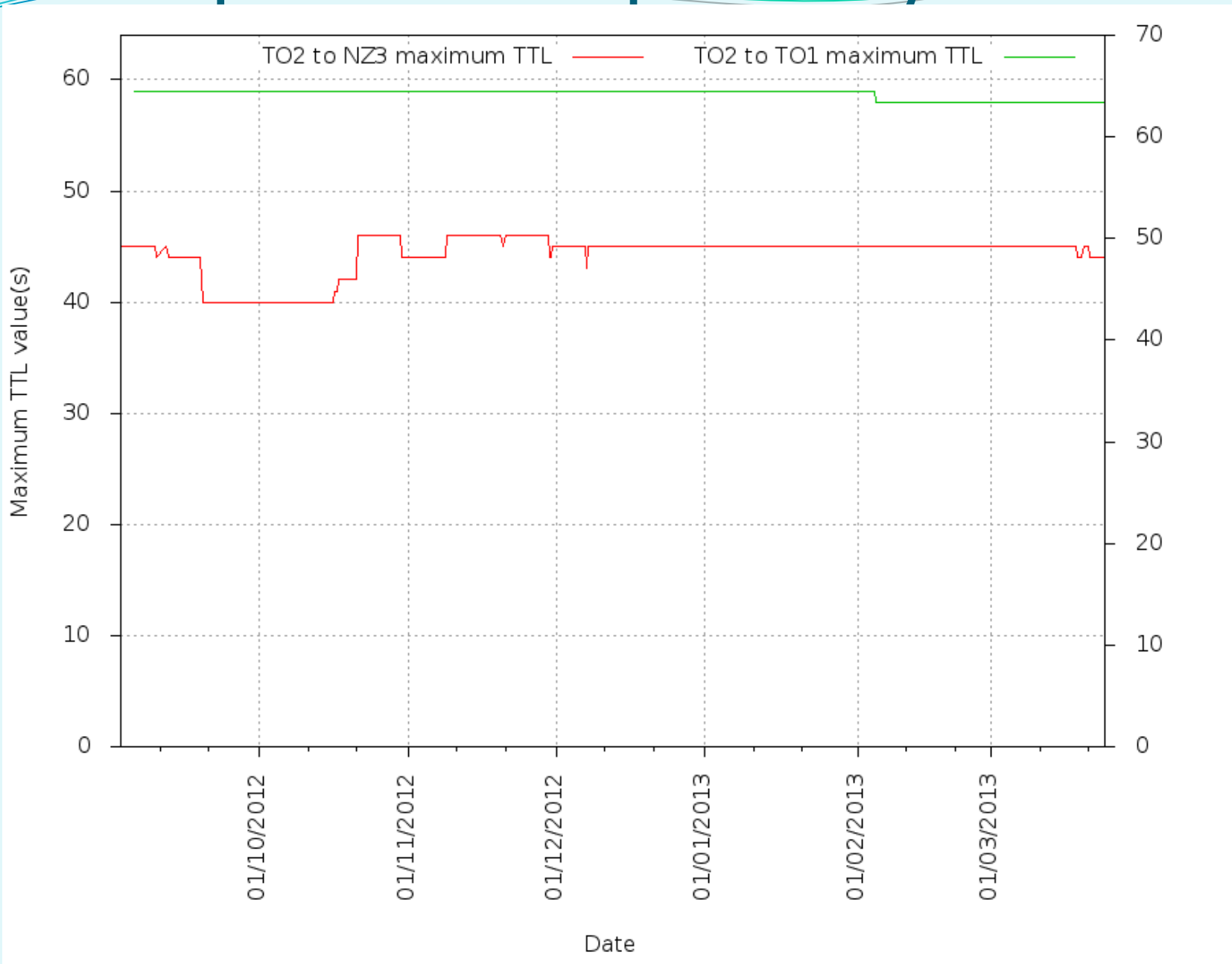
Measurement of Jitter

- E.g., beacon software transmits and receives synthesised UDP packets with sequence numbers and timestamps every 20 milliseconds (10,000 packets in one experiment)
- 3 experiment runs per day
- Compute jitter from timestamps logged

Example: Transit Jitter



Example: Packet pathways - TTL



Packet Train Arrival Entropy

- What is entropy?
  - Predictability of arrival timing
  - Recurring patterns in arrival timing
- Provide example of entropy

Entropy Measures

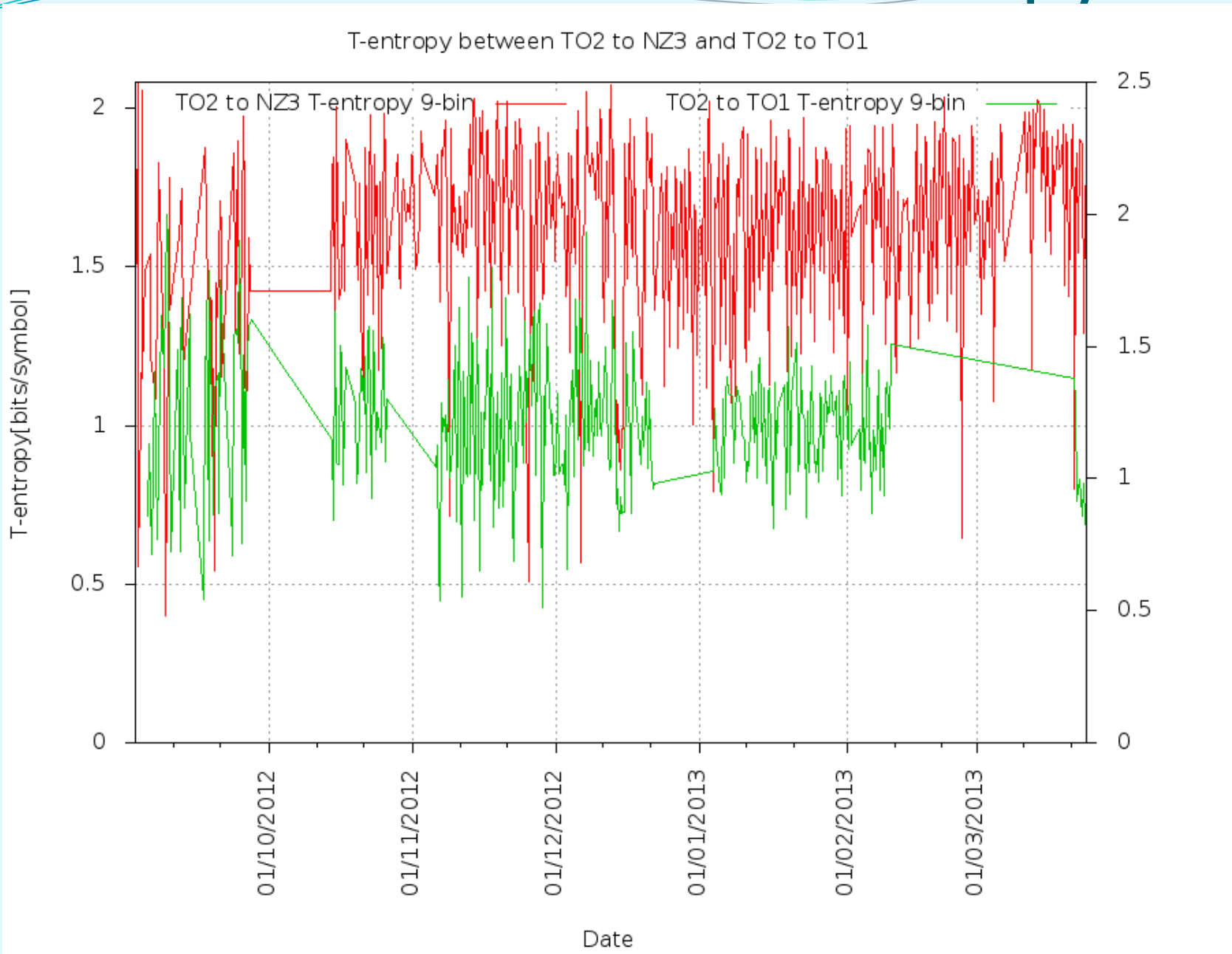
- Need to produce a string (or sequence of symbols) – think of this as a Shannon "source"
  - E.g., We have the following threshold
  - A = inter-arrival time 0- 15ms
  - B = inter-arrival time 15-18ms
  - C = inter-arrival time 18-22ms
  - D = inter-arrival time 22-25ms
  - E = inter-arrival time > 25ms
- Then map inter-arrival times to symbols to get following results

Packet no.i	Arrival timestamp (ri)	Difference Inter-Arrival Time	Symbol
0	(packet lost)		
1	1348001461.691		
2	1348001461.717	26	E
3	1348001461.738	21	C
4	1348001461.760	22	C
5	(packet lost)		
6	1348001461.821		
7	1348001461.828	7	A
8	1348001461.848	20	C
…	…	…	…

Jitter to Entropy

- Then: Compute entropy from string (Shannon, T-entropy, LZ compression ratio)
- Entropy is able to classify more complex patterns as 'normal' that pure jitter measures would consider random
- Example on previous slide maps to x = ECDEAC, If string contain all CCCCCC then jitters are normal since we transmit every 20 milliseconds.
- "Real" strings are up to 9999 symbols long!

Result : Inter-arrival T-entropy



Beacons Long Term

- Trends in jitter: Will jitter increase or decrease over time?
- Trends in TTL: Will multipath propagation increase as additional links are added?
- Trends in entropy: Will arriving data streams become less predictable?
- Intend to measure for many years to come

Conclusions

- Beacons provide tool for monitoring long term developments of jitter and entropy

Thank You

Questions?