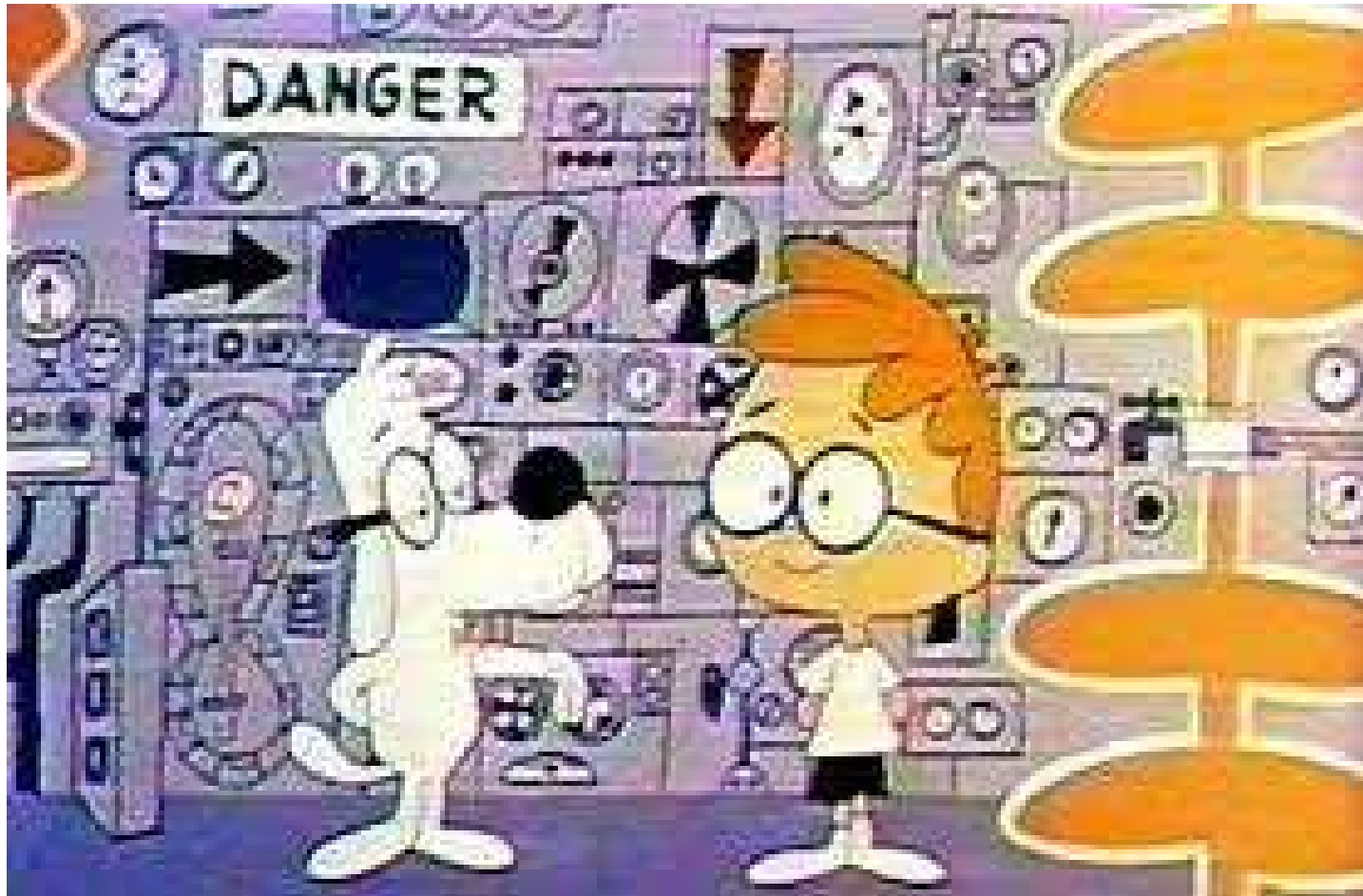# Time Determination
It's about time

Charles Barry

Topics

- ## WABAC Machine
  - *It was about time*
- ## Time Determination
  - When an event occurred, not what time is it
- ## Future Efforts
 - IP Intelligence - when and *where*

WABAC Machine

- Stanford STARNET 1992-1994
  - Constant Bit Rate services over packets
- NUKO Digital Video Multiplexer 1996
  - Constant Average Rate services over packet
- Luminous Networks 1999-2006
  - 802.17 => Layer 2 Synchronization
  - World's first deployed TDM Pseudowire
  - Multi-Service Packet Platform - Voice/Video/Data
- Brilliant Telecommunications 2006-2011
  - NTP/PTP Time Distribution for Femtocell, Basestations
- Jolata
  - Per Packet network performance monitoring
    - => Time Determination Patent
- Luminous Cybernetics 2018
  - IP Intelligence

Time Distribution vs Determination

- Time Distribution
  - What time is it here?
    - NTP => PTP => timesyncd
      - Trend is worse, not better!

- Time Determination
  - When did it happen there?
    - Completely new analytics method

Time Determination - Fingerprint & Analyze
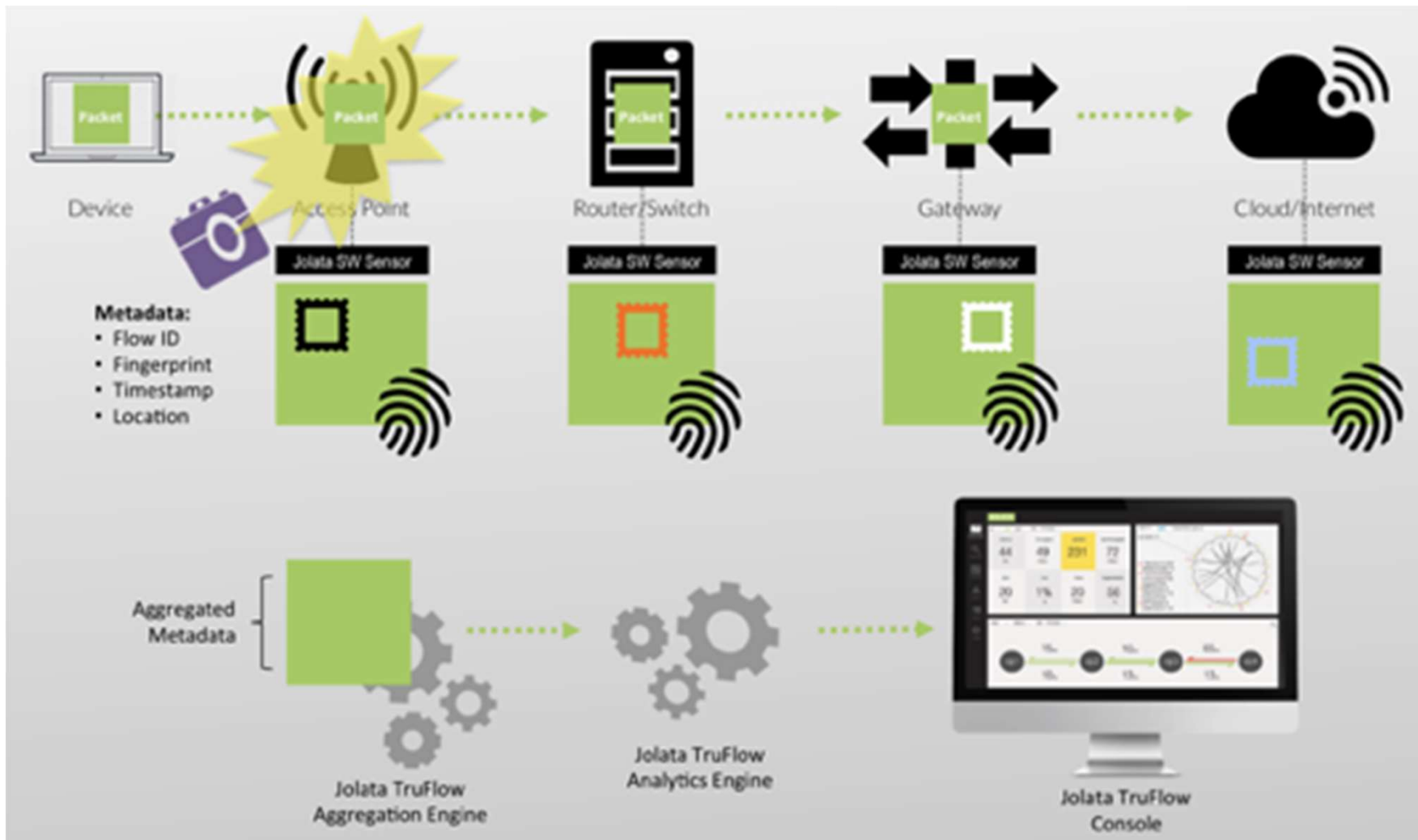
Packets are fingerprinted, metadata send to aggregation point
Time determination is done at the aggregation point
Timestamps need not be synchronized!
Only requirement is for monotonically increasing timestamp clocks

Time Distribution vs Determination - Protocol

- Time Distribution
  - IEEE1588, etc.
  - Hierarchy of Master; Boundary; Ordinary
    - Configuration, setup, scale limits, failover considerations

- Time Determination
  - Per Packet Processing of Spanned/Tapped packets
    - Built in to Cloud infrastructure - one click to deploy across an entire cloud - every VM, every data center, cloud scale
  - No Protocol
 - Proprietary, Patented

Time Distribution vs Determination - Packet Rate

- Time Distribution
  - Relatively small rates, 8/s; up to 1024/s
  - Performance gets worse with load

- Time Determination
  - => 50M packets per second or more!
  - Performance gets better with load!
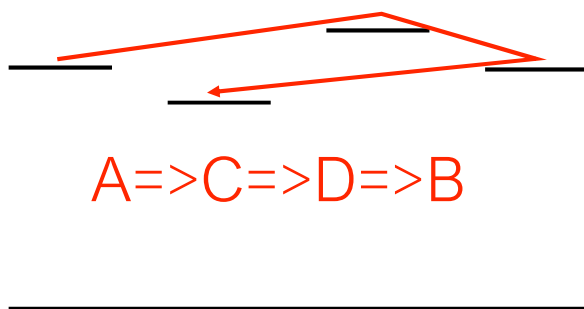
Time Distribution vs Determination - Packet Size

- Time Distribution
  - Fixed, small packets ~100B
    - Impacted by Store and Forward delays
    - ***Terrible choice for packet timing!***

- Time Determination
  - All packets are fingerprinted; metadata retains packet size
    - => small packets for lowest minimum time
    - => large packets for least jitter
   - => extrapolate delay of a "zero byte packet"
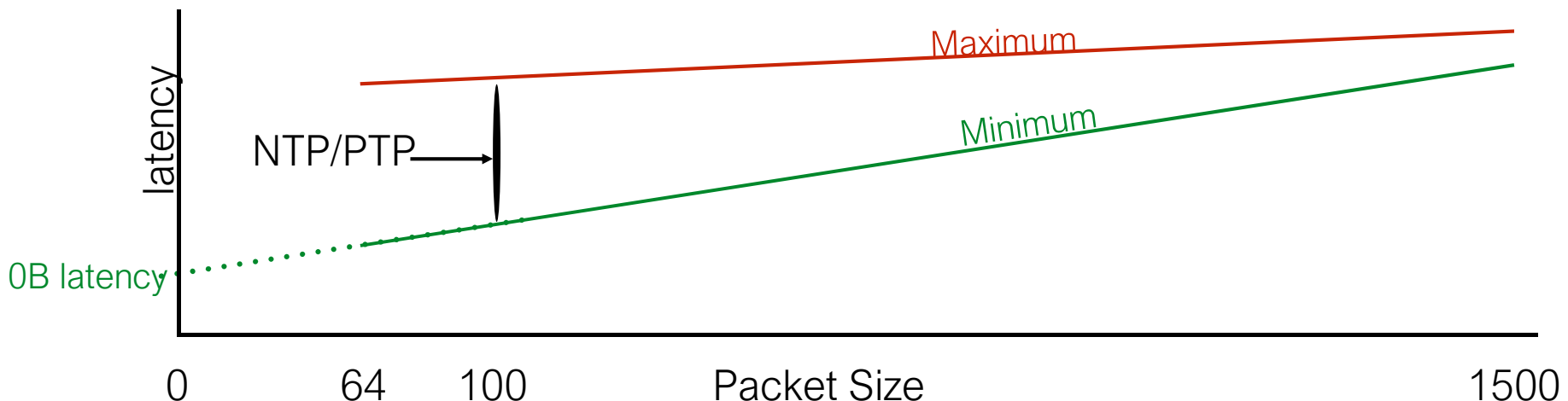
Time Distribution vs Determination - Causality

- Time Distribution
  - Each client recovers time independently
    - No coordination means *no causality*
    - A=>B; A=>C; A=>D ≠ A=>B=>C=>D

- Time Determination
  - Packet's path is traced analytically (IP TTL)
  - Asymmetric offset is determined that *ensures causality*
    - A=>B=>C=>D
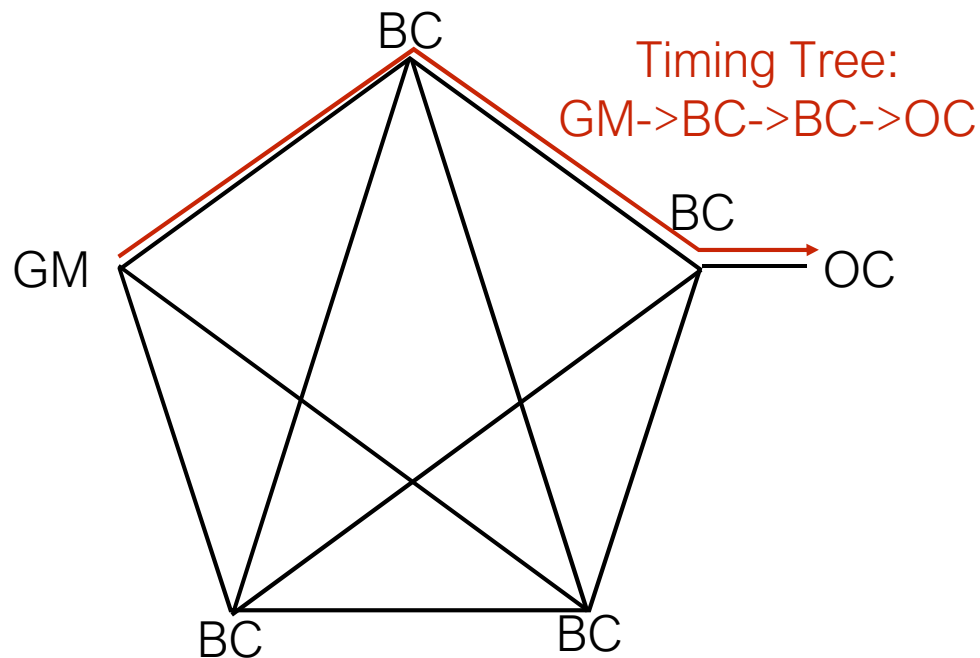
Time Distribution

A=>C=>D=>B

Time Determination

A=>B=>C=>D
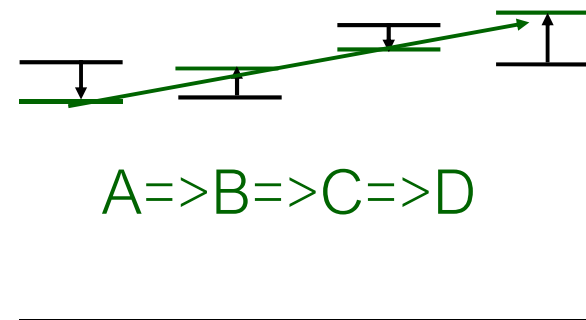
Time Distribution vs Determination - Topology

- Time Distribution
  - Tree Hierarchy; Cascaded
    - Each level is no more accurate than previous
  - Subject to Traffic Congestion, link loss, re-route
- Time Determination
  - More links provide more opportunity for lucky packets
  - more links => more packets => more lucky packets
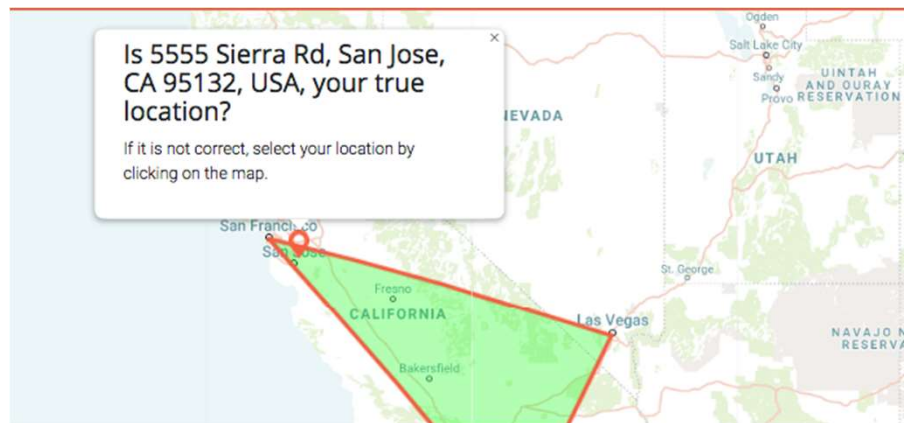 - Global Causality bounds asymmetry

Time Distribution

BC

Timing Tree:
GM->BC->BC->OC

BC

GM

OC

BC   BC

Time Determination

Node

Node   Node

Node

Node   Node
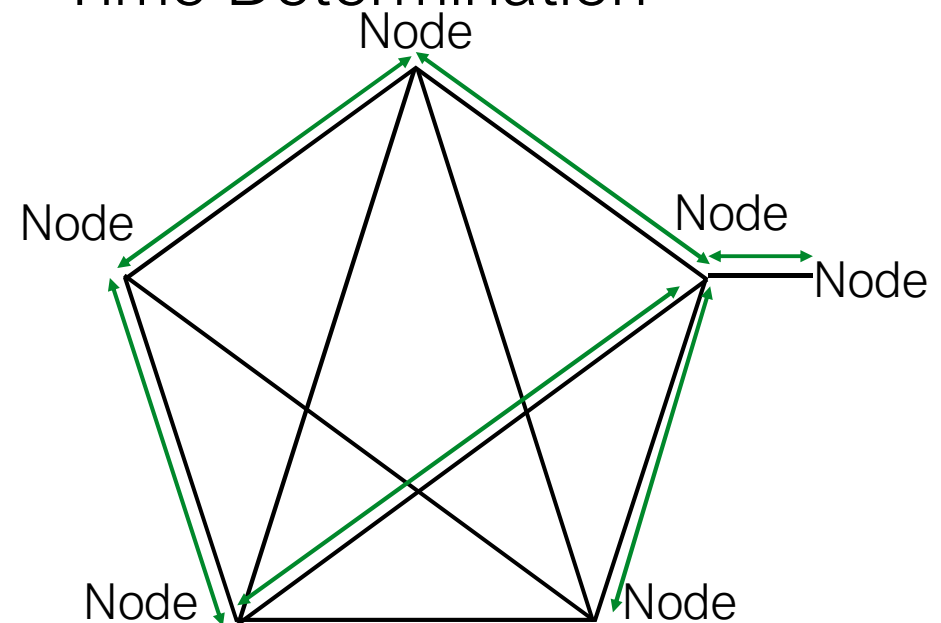
Time Distribution vs Determination - Summary

Feature	Distribution	Determination	Determination Benefit
Recovery	Every Client	Centralized aggregator(s)	No need to distribute time nor recover it in any way at a client
Protocol	NTP, PTP, etc	None	Minimal setup/config
Packet Rate	1024/s max	per packet; up to full wiresepeed/link rate >50Mpps	More packets, varying sizes, the better the results
Packet Size	Fixed, small	Any	Reduced uncertainty; improved stability
Causality/Ay smmetry	Some systems provide a static offset (calibration done offline)	Asymmetry automatically determined to ensure causality	Determination algorithm uses causality to determine asymmetry!
Topology	Hierarchical; One reference source at a time	More links the better! Reference-less	Rings, linear, mesh

Future Efforts - IP Intelligence

- Where is just as important as when
  - General Data Protection Regulation
    - User's Data Privacy is Paramount
    - Restrict/block access from Embargo'd countries

- Technique
  - Client Presence Verification:
    - e.g., http://159.65.33.162/cpvwebsite/

Is 5555 Sierra Rd, San Jose, CA 95132, USA, your true location?

If it is not correct, select your location by clicking on the map.

You are: Inside the triangle

Time Determination
It was about time