An Empirical Study of Clock Skew Behavior in Modern Mobile and Hand-Held Devices

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Goal - Signature Based Recognition

Identification of all active devices operational in a network, by extracting timing information.

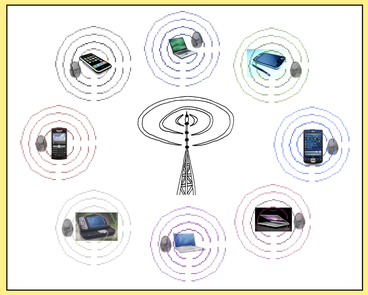

Fig 1. Illustration of device identification concept.

Applications

- Host identification – flag a malicious device.
- Count number of active hosts in a network.
- Existence awareness of vital servers on n/w.
- Virtual-to-physical machine mapping in data center environment.

Motivation

- Mobile Device Proliferation - Enterprise Boundary Liquidification.
- Device Identity essential to flag malicious activity for scrutiny by NIDS.
- Transmission signature requires proximity, extract non-spoofable timing information.

Salient Features

- Simplification of clock skew measurement.
- Bar on allowed % error in latency - finer precision.
- Resource Constrained - unpredictable delays (send packet trains).

Wireless	Laptops, netbooks
Smartphones	Android 2.1, Samsung Galaxy GT-9000 Symbian 3 , Nokia N8

Clock Skew Evaluation

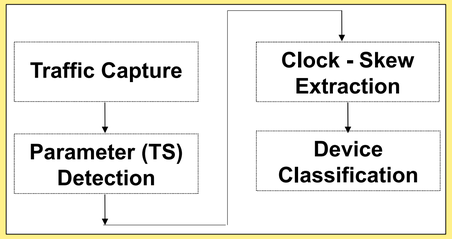

Fig 2. Skew Evaluation Skeleton.

Nomenclature - Kohno, Moon

$$ArrivalTime(M) :: xi = ti - t1 \quad (1)$$

$$Timestamp(T) :: vi = Ti - T1 \quad (2)$$

$$InterruptTimerFrequency(T) :: Hz \quad (3)$$

$$Observedoffset(ithpacket, T) :: yi = wi - xi \quad (4)$$

$$OffsetSet :: OT = (xi, yi)|ibelongsto1, ...|T|. \quad (5)$$

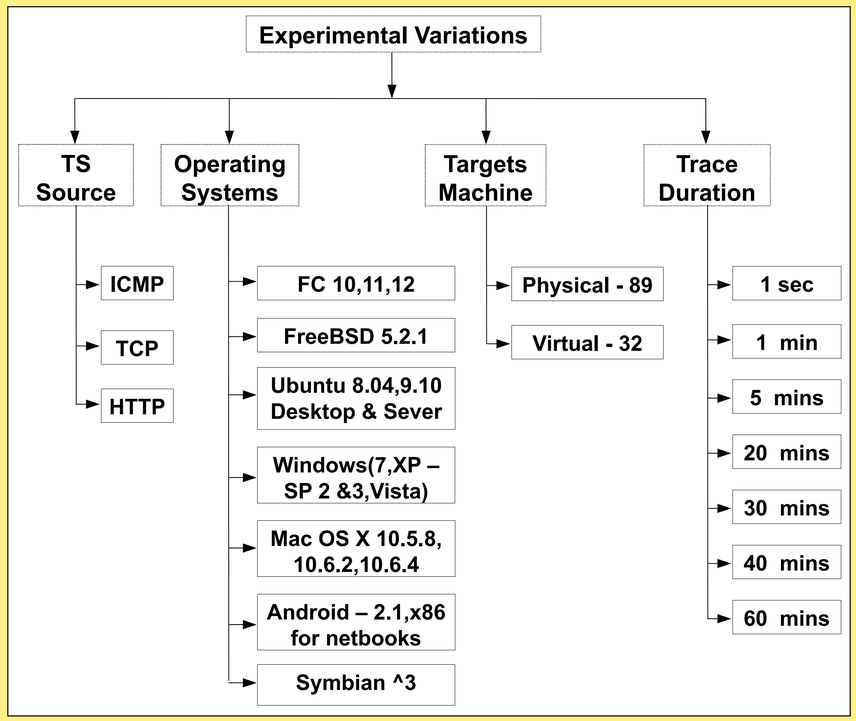

Fig 3. Configuration variations for experiment.

Skew Behavior

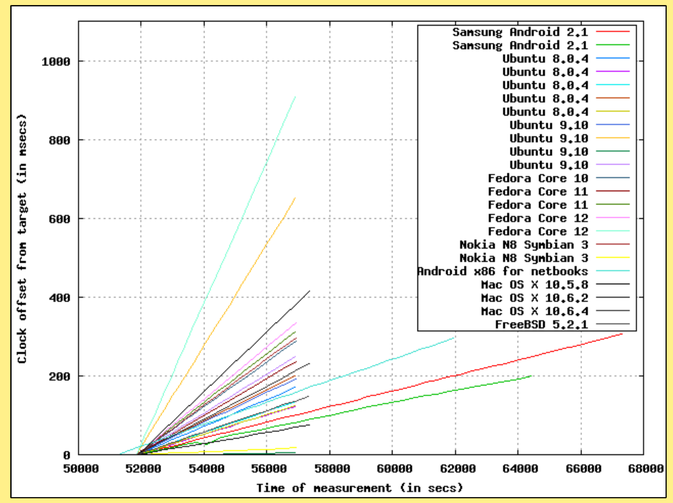

Fig 4. Unique Skew for devices - same h/w & s/w specifications.

Results

- **Accuracy** - 0.3-0.4 ppm (down from 0.67).
- **Diversity** - Unique, non-spoofable skews.
- **Stability(Temporal,Spatial)**-Repeated measurements.
- **VM Skews** - Consistent with underlying machine.
- **Topology Change Resistant** - WiFi & EDGE n/w.
- **Latency Tolerant** - Last mile wired/wireless.
- **Time Synchronization** - Small change with NTP.
- **Trace Duration Resistant** - Beyond Threshold.
- **Temp., CPU Load Change Resistant** - 0.1-0.3 ppm.

Further Information

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