**Objective**

Ability to compare consecutive runs of an experiment – configuration & output data.

**Motivation**

- **Experiment components** -
  - **Deterministic** – simple computer programs.
  - **Non-Deterministic** – dynamic w.r.t. behavior.
  - **Opportunistic** – attack models.

- **High-level aggregate metrics** -
  - Fail to capture complex configuration dependent dynamics.

**Fundamentals**

- **Deterministic** - Agg. Properties - BW/s, loss, jitter, latency.
- **Deterministic** - Identify key aspects - 1-to-1 comparison or temporal/interval Based ordering.
- **Probabilistic** - Stochastic Process parameters; approaches - Markov Models, HMMs, Petri nets.

**1st-Order Markov Model**

\[
\begin{align*}
\text{M}(x) & = \{S, IS, A\}, IS \subset S \quad (1) \\
\text{P}(q_{i}) & = S, q_{i}, \ldots, S, q, \ldots = S, i, \ldots] \quad (2)
\end{align*}
\]

- **Eqs (1)**: \( \text{M}(x) = \) Markov Model, 'S' = finite set of states, 'IS' = set of initial states, 'A' = Transition Prob. Matrix.
- **Eqs (2)**: \( \text{M}(x) = \) Sequence of stochastic events; state -
  - Dictated only by previous state.
  - Independent of path followed.

\[v_{r}, i = \text{sum (all probabilities from a state)} = 1. \quad (3)\]

**Model Creation**

- Obtain S (distinct minimal N-tuple unique packets), IS & A.
- Populate state transition diagram, save model.

- Create model from several runs - ensure statistical soundness.
- Generate \( \text{M}'(x) \), find \( \delta \) (degree of variability b/w experiment runs) – (4).

\[\delta = \sum_{i} |\text{M}(x) - \text{M}'(x)| \quad (4)\]

- Lower \( \delta \) → closer match between experiment runs.

**Results - Experiment & Sample Data**

- **Experiment Variations**:
  - **I. Topological Variations** -
  (a) 'authNS' - same subnet as 'victimNS'.
  (b) 'authNS' - same subnet as 'realbank' (global w.r.t. 'victimNS' subnet).

- **II. Cross-Traffic Variations** -
  (a) No Background Traffic.
  (b) Additional DNS Traffic.

- **Error Bars** – Min, Median, Max – lowest to highest value.

**Results**

- Comparison with same config. \( \Rightarrow \) negligible \( \delta \) (i.e. A/B/C).
- Comparison with different config. \( \Rightarrow \) high \( \delta \) (~ 0.08 for D/E/F).
- So, small \( \delta \) → same exp’t runs; large \( \delta \) → changes in exp’t config. or comparison with different exp’t.

**Future Work**

- Comparing exp’ts in simulations, emulations to cover all kinds of experimental methodologies.
- k-order MM/HMMs \( \Rightarrow \) complex exp’ts.