# Effectiveness of Moving Target Defense Techniques to Disrupt Attacks in the Cloud

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## Cloud

- Offers access to resources (services, data, storage, etc.) over the Internet as utilities.
- Is a complex environment entailing both physical and virtual resources.
- Has a multitude of attack surfaces and dynamic threat propagation pathways.

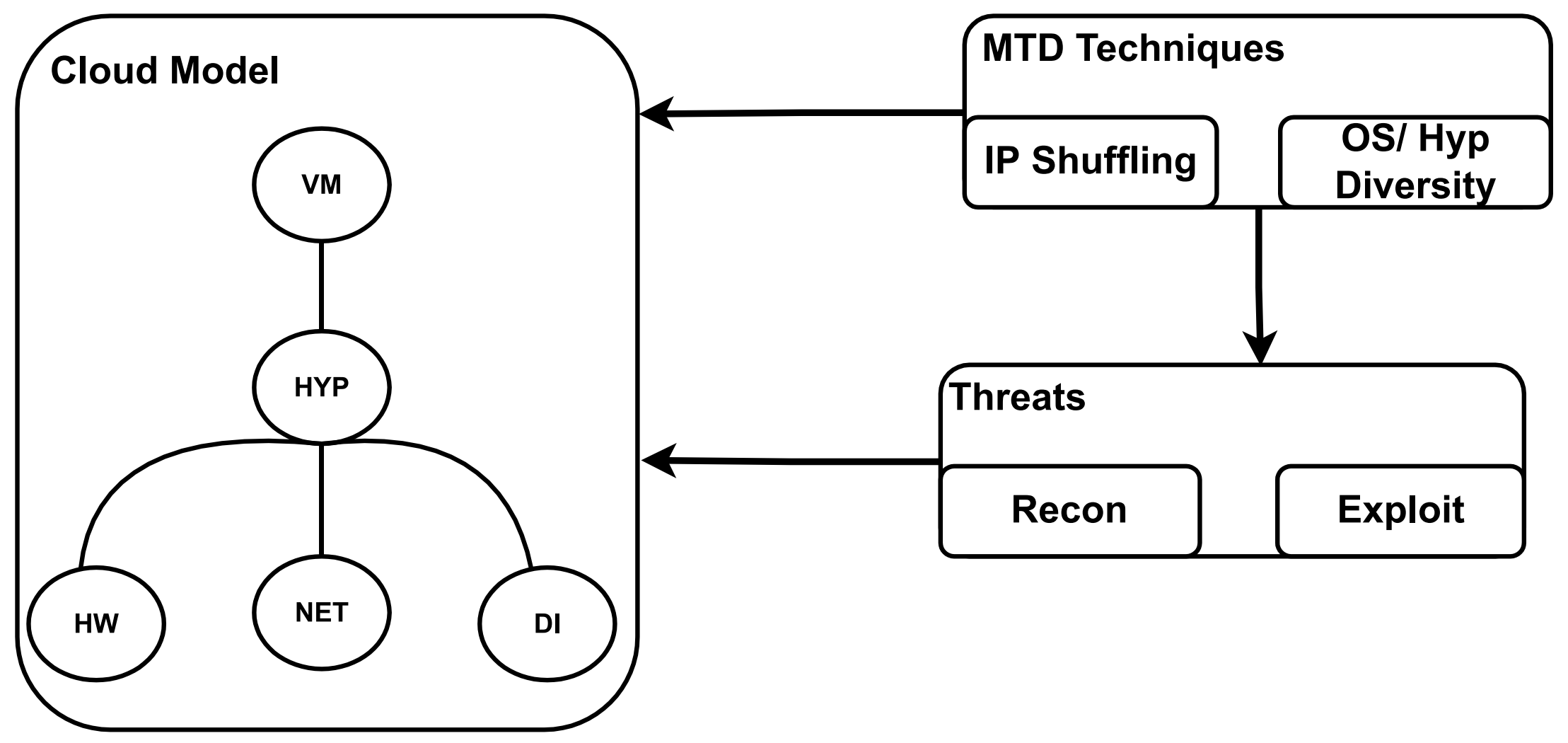
### State of the Art

- Moving Target defences (MTDs) can proactively mitigate threats by dynamically changing attack surfaces (e.g., shuffling IP addresses to increases complexity during the reconnaissance step).
- MTDs deployment is limited to individual components instead of system-wide deployment.

### Our Contributions

- We proposed deployment of MTDs across different layers of the Cloud to evaluate the overall security gains at the system level.
- A novel approach to explore the optimal placement for deploying MTDs across the Cloud operational stack.
- Proposed a quantification method to determine the effectiveness in disrupting single- and multi-stage attacks.

### MTD Framework



Multi layer MTD framework

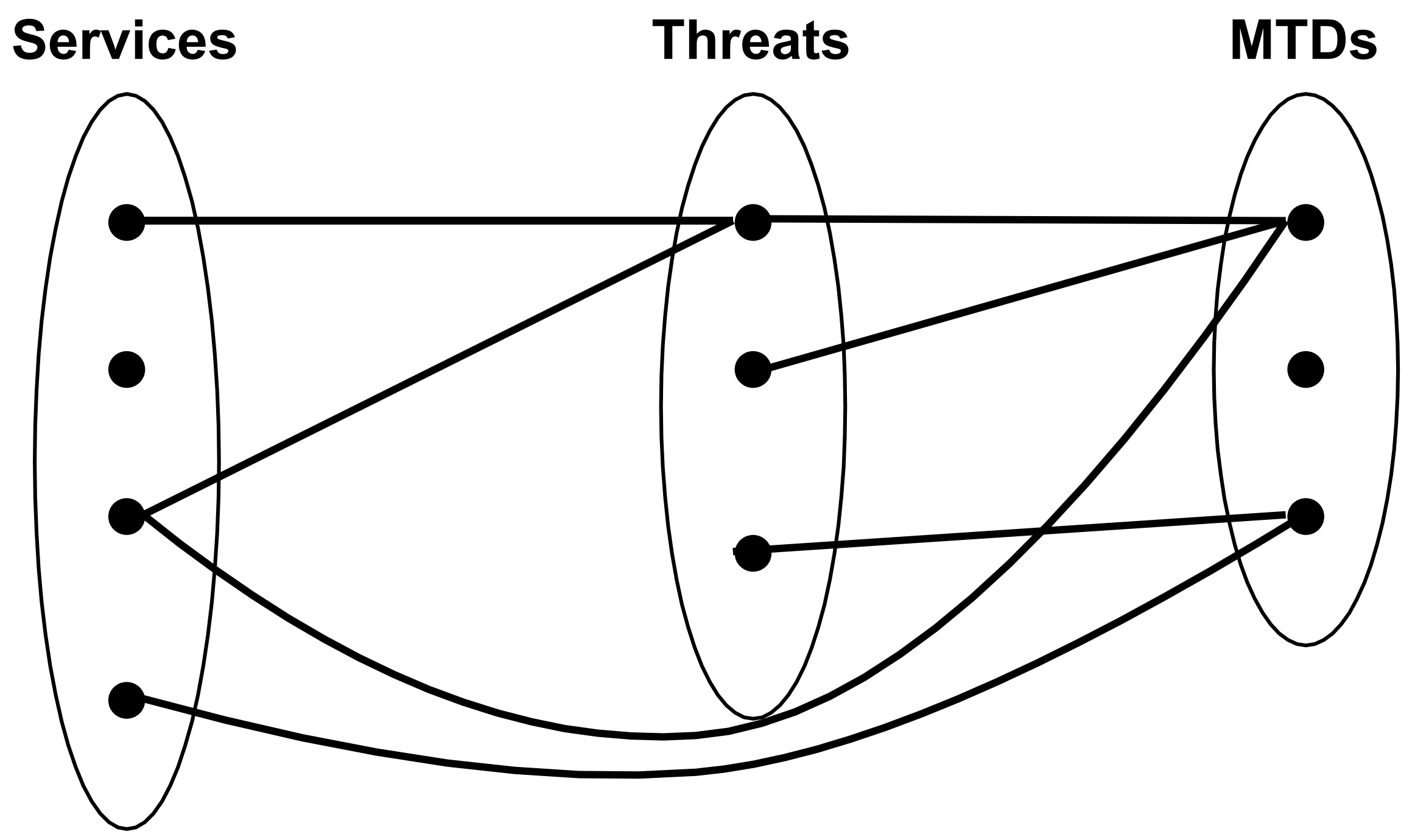
## Multi-layer Framework

**Cloud Model:** Modelling the interaction and information flow among the services to demonstrate the functional behaviour of the Cloud.
**Threats:** Contains threats that can target services in the Cloud. The threats are taken from the national vulnerability database.
**MTD Techniques:** A list of deployable MTDs techniques, e.g., IP Shuffling, OS diversity, etc.

### Relationship Among Layers

The layers and their relationships can be modelled as a 6 tuple (M, T, S, $R_{mt}$, $R_{ms}$, $R_{ts}$) where

- M is a finite set of MTDs
- T is a finite set of threats.
- S is a finite set of services in the Cloud.
- $R_{mt} \subseteq M \times T$ : Impact of MTDs on threats.
- $R_{ms} \subseteq M \times S$ : Applicability of an MTDs on services.
- $R_{ts} \subseteq T \times S$ : Identifies the threats targeting services.



Relationship among the layers

- A threat can impact a single service or multiple services.
- An MTD can impact a single threat or multiple threats.
- An MTD can be deployed or a single or multiple services.
- Therefore the relationship among the layers is many-to-many and finding the most effective solution can be formulated as an optimization problem.

## The Optimization Problem

- Maximize E($M_m$, $T_t$, $S_s$) ; Effectiveness of MTD against a threat targeting a service.
- Minimize C($M_m$, $S_s$) ; Deployment cost MTD on a service.
- Subject to constraints C1, C2, and C3.

where

- The effectiveness can be defined as:

$E(M_m, T_t, S_s) = (T_t, S_s) \in R_{ts} \wedge (M_m, T_t) \in R_{mt} \wedge (M_m, S_s) \in R_{ms}$

- The cost can be calculated as:

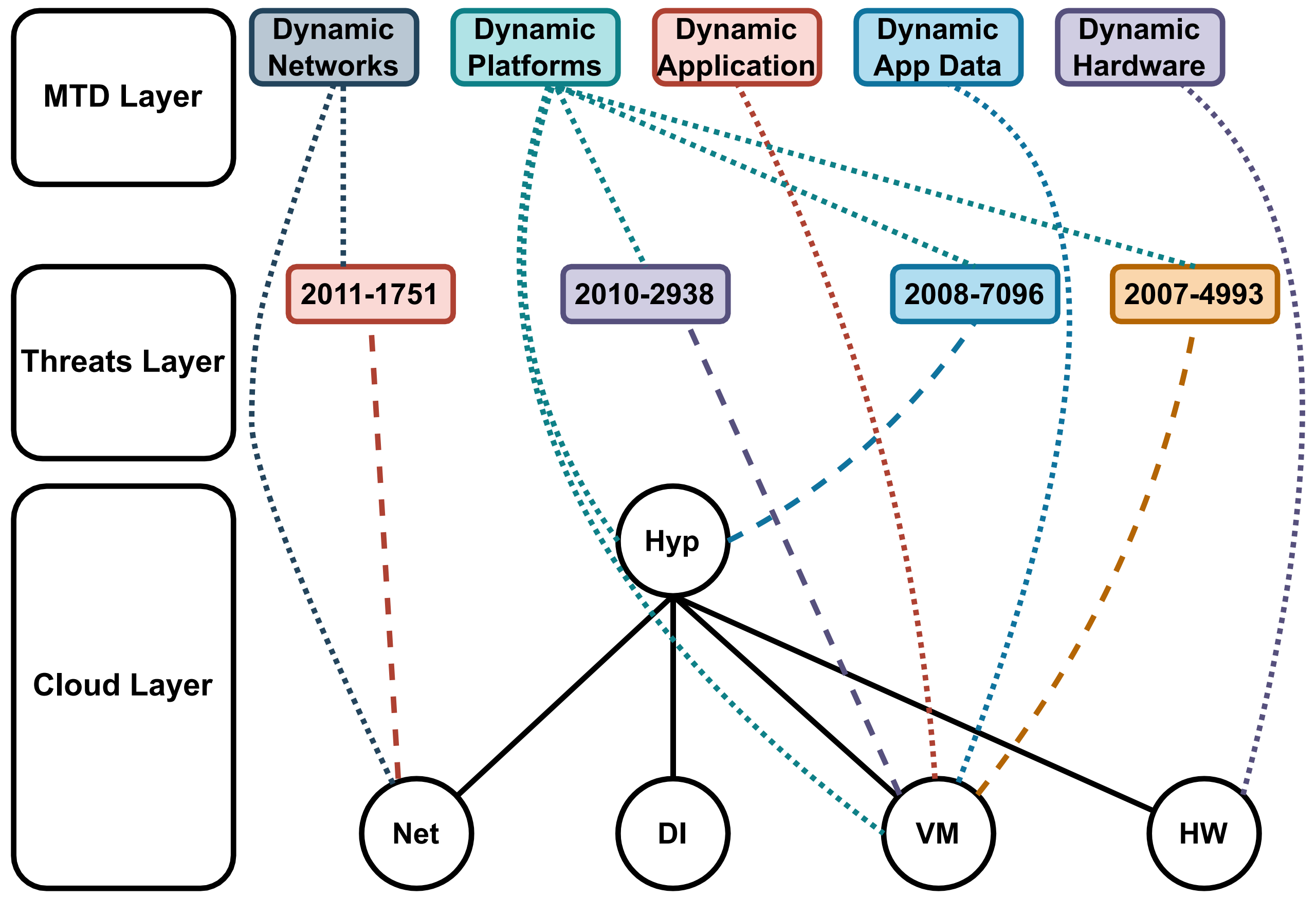
$C(M_m, S_s) = \mathit{Deployment}(M_m, S_s) + \mathit{Overhead}\,(M_m, S_s)$

- The constraints are:

C1 (System's Constraint): Proper termination of the system.
C2 (Attacker's Constraint): A threat with maximum likelihood is used by an attacker at any given time.
C3 (Defender's Constraint): An MTD can only be used if it can target a threat and is deployable on the targeted service.

### Security Analysis

- Solving the optimization problem to identify optimal MTDs placement for single-stage attacks.
- Extending the problem statement to cover multi-stage attacks by using dynamic programming.



Single-stage attack

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