A Naming Service Architecture and Optimal Periodical Update Scheme for Mobile Agent System

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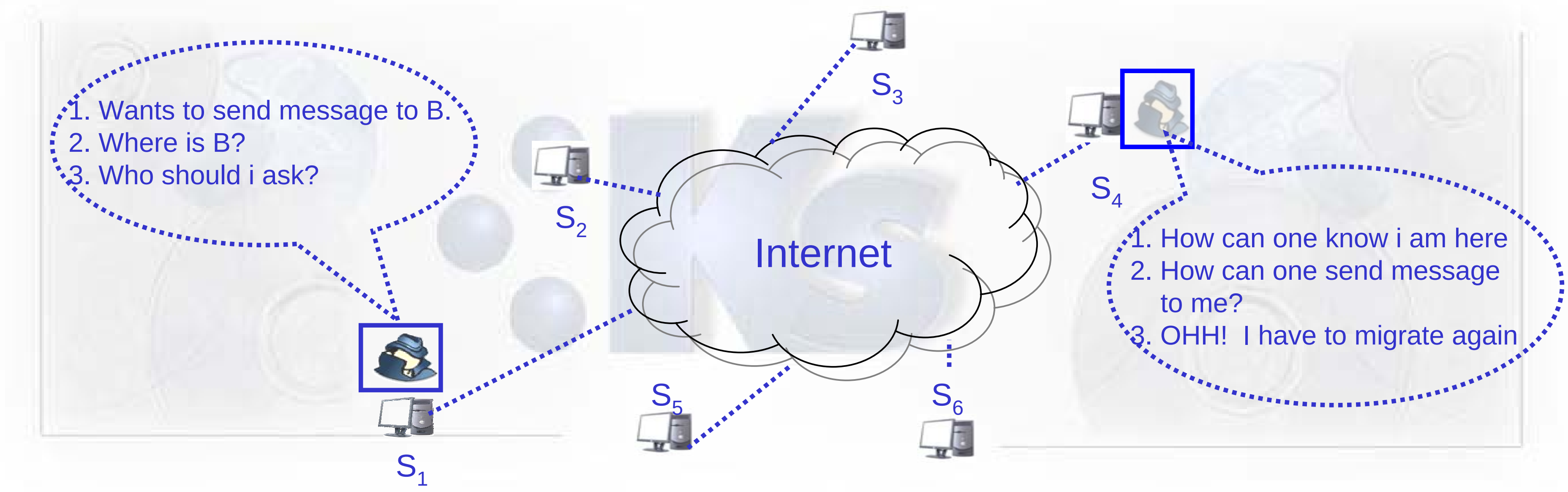
Agenda

- Motivation
- Background & Problem Statements
- Naming Service Architecture Design
- Optimal Periodical Time Threshold Calculation
- Summary

Motivation

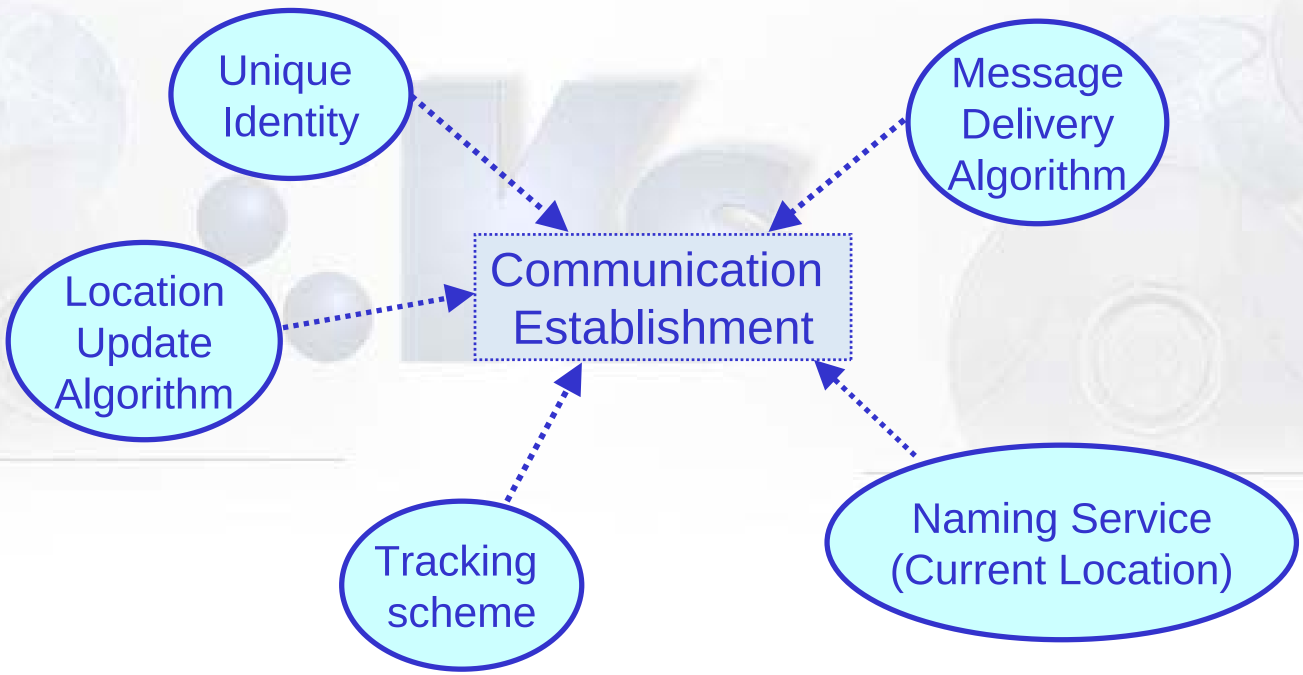
Mobile agent communication: e.g. messaging



Background & Problem Statement (1)

Communication:

- Synchronous : Dialoque
- Asynchronous : Message Passing



Background & Problem Statement (2)

Unique Identity: one name implies one mobile agent.

Problems:

- Impersonation
- Conflict in message delivery scheme

Existent Countermeasures:

- Hash function
- DNS-style

Approach: PKI and Digital Signature

Background & Problem Statement (3)

Naming Service

Task: After receiving the location request, it must return an addres, e.g. IP of the visited host, to the requestor.

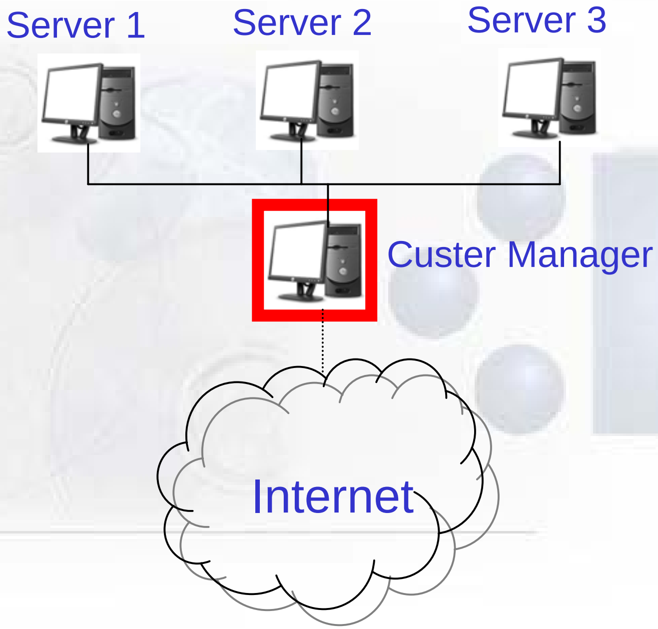
Architecture:

- *Centralized*
  - A cluster of Servers
  - A Server
- *Distributed*
  - GD Clusters of Servers
  - GD Servers

GD: Geographically Distributed

Background and Problem Statement (4)

Centralized: One (cluster) localized Server(s)

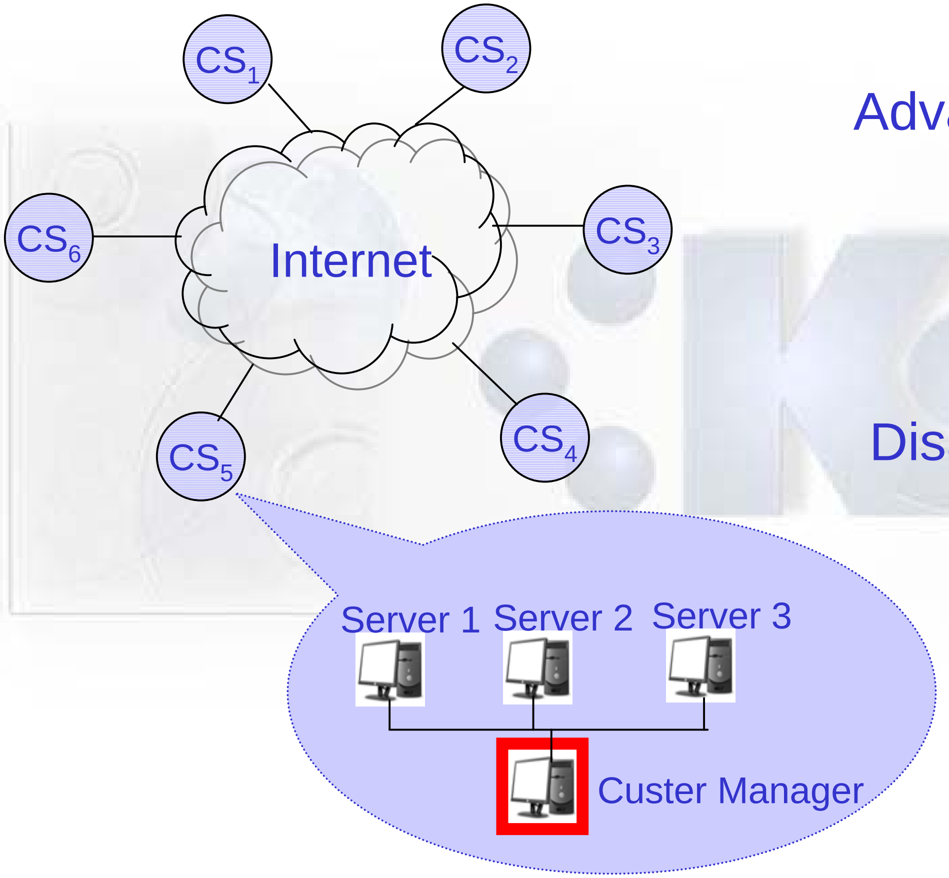


Advantages:
1. Easy management
2. Load balancing (cluster)

Disadvantages:
1. Bottleneck
2. Service unavailability

Background and Problem Statement (5)

Distributed: Geog. dispersed (cluster) Server(s)



Advantage

1. Support global scale system
2. Load balancing (cluster)

Disadvantage

1. Complex Management
2. High Implementation Cost

Background and Problem Statement (6)

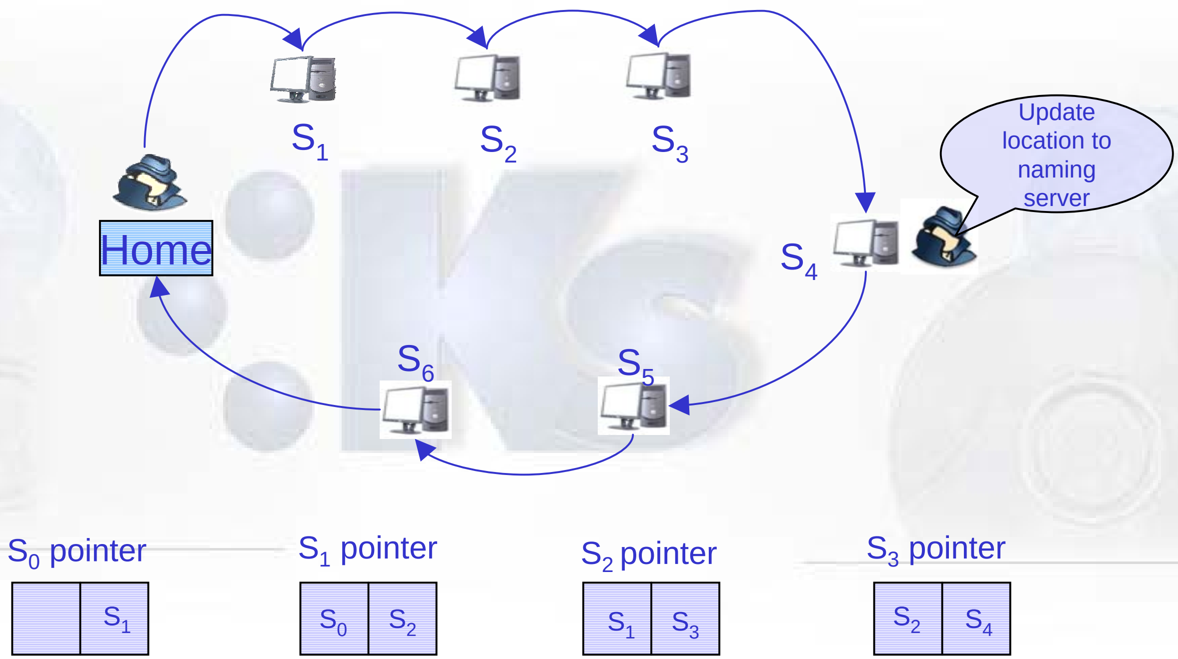
Location Update Algorithm:

1. Simple update
2. Movement-based update
3. Time-based update

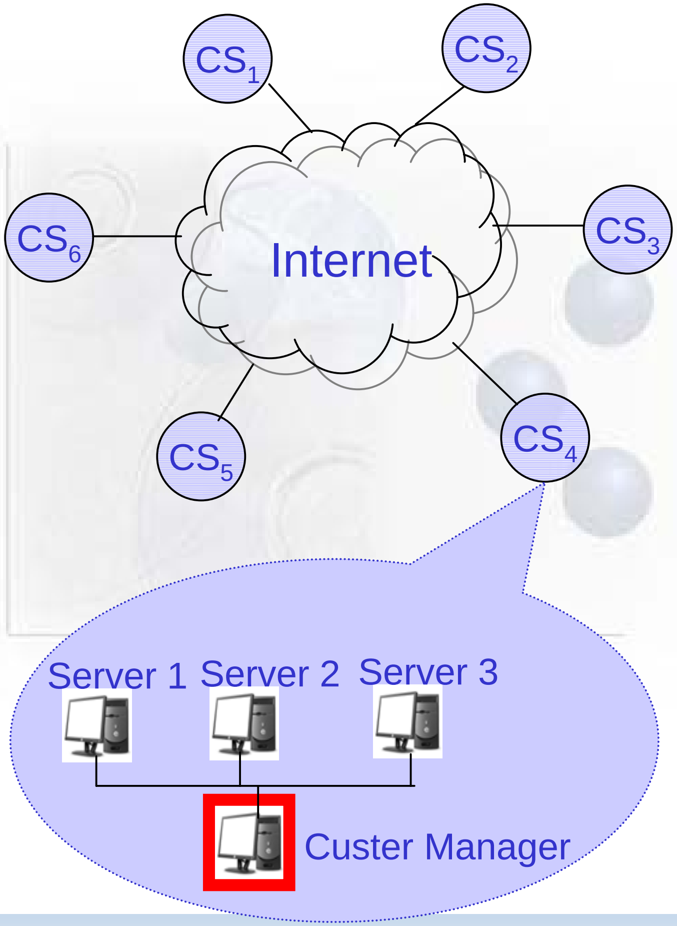
Tracking Mechanism: Forwarding Pointer

Background and Problem Statement (7)

Time-based update + Forwarding scheme



Naming Service Architecture Design



Design Objectives:

- Naming Function
- Server selection & Load Balancing
- Current location Retrieval
- Location Update

Naming Function

Name‘s Properties: Singularity and Unpredictability

$$\text{Owner} \rightarrow \text{Selected Cluster}:$$

$$R = ENC_{Cluster}[Sig_{Owner}[R_n, \text{Kernel}, \text{Agent's Information}]] \qquad (1)$$

R_n = Readble name

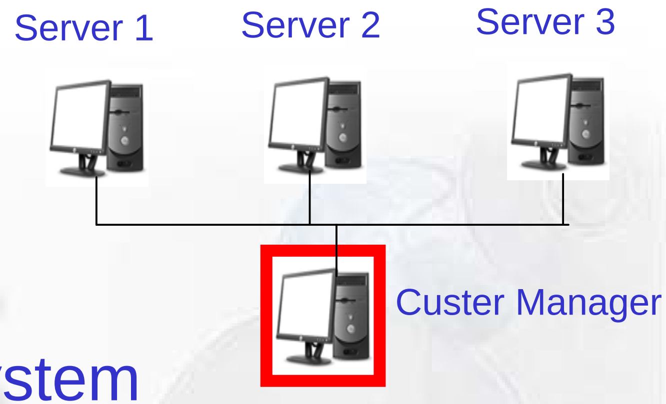
Kernel = Initial values and Codes

Agent‘s Information = Task, Ability, Optimal Time Threshold
Number of Updates and Lifetime

Server Selection and Load Balancing (1)

Server Selection:

1. Round Trip Time (RTT)
2. Number of hops
3. Number of administive system



$$I_C = \min_{i=1}^{N} \left\{ (\alpha * RTT_{CS_i} + \beta * N_{CS_i}) \right\} \quad \text{with } \alpha + \beta = 1 \qquad (2)$$

Server Selection and Load Balancing (2)

Dispatching Policy: Static or Dynamic

- Static algorithm: Random or Round-Robin
- Dynamic algorithm: State information, e.g. Queue length CPU utilization etc....

Current Location Retrieval

Current location request:

$$\text{Requestor} \xrightarrow{\text{Message}} \text{Cluster}:$$

$$LR = ENC_{Cluster}[Sig_{RH}(R_N, \text{Owner's PublicKey}, \text{RH's Identity})] \quad (3)$$

Current location:

$$\text{Cluster} \xrightarrow{\text{Message}} \text{Requestor}:$$

$$CL = ENC_{RH}[Sig_{Cluster}(R_N, \text{Owner's PublicKey}, \text{Kernel}, \text{Location}, \text{Remaining time to update})] \quad (4)$$

Optimal Time Threshold Calculation (1)

T_{H_i} = Host Residence Time.
Independent identically distributed random variable (iid rv.)

$F_H(T_{H_i})$ = General Distribution function of T_{H_i}

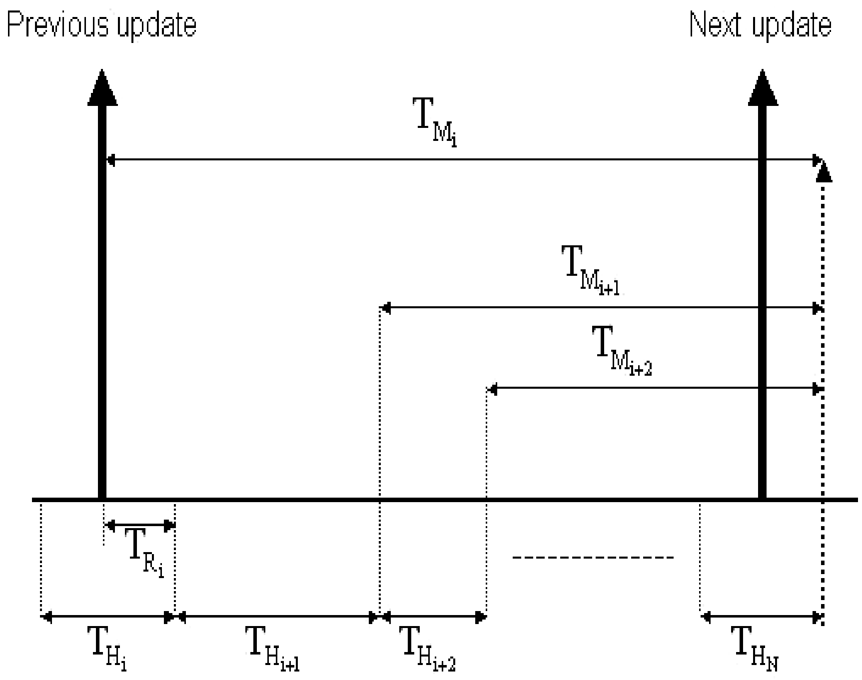
$f_H(T_{H_i})$ = Probability Density function T_{H_i}

$R_R(T_{R_i})$ = General Distribution function of T_{R_i}

$r_R(T_{R_i})$ = Probability Density function of T_{R_i}

$$E[T_{H_i}] = \frac{1}{\lambda_{H_i}}$$

T_{M_i} = Forwarding Pointer Maintaining Time



Optimal Time Threshold Calculation (2)

$$C_{up} = U * \left\lceil \frac{T_{Life}}{\tau} \right\rceil \quad (5)$$

$$C_M = M * \left\lceil \frac{T_{Life}}{\tau} \right\rceil * \left[\sum_{i=1}^{\infty} v(i) * \left[E[T_{R_1}] + \sum_{j=0}^{i-1} j * E[T_{H_{j+1}}] \right] \right] \quad (6)$$

T_{life} = Mobile agent's Lifetime

U = Cost of performing a location update

M = Cost of maintaining forwarding pointer per unit of time

τ = Optimal time threshold $0 < \tau \leq T_{Life}$

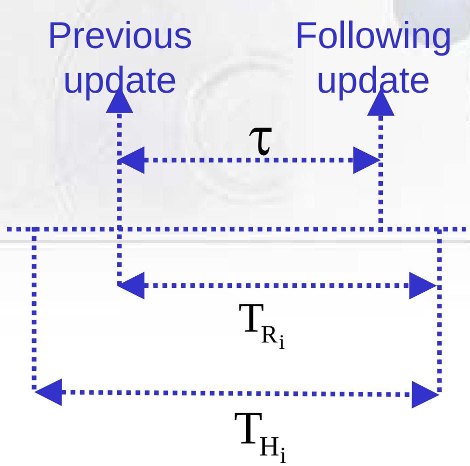
V(i) = Probability there are i visited hosts between two location updates

Optimal Time Threshold Calculation (3)

$$T\_Cost(\tau) = C_{UP}(\tau) + C_M(\tau)$$

$$= U * \left\lceil \frac{T_{Life}}{\tau} \right\rceil + M * \left\lceil \frac{T_{Life}}{\tau} \right\rceil * \left[\sum_{i=1}^{\infty} v(i) * \left[E[T_{R_1}] + \sum_{j=0}^{i-1} j * E[T_{H_{j+1}}] \right] \right] \quad (7)$$

- Derivation of v(i), when i = 1



Calculation of $r_R(T_{R_i})$ using renewal theory

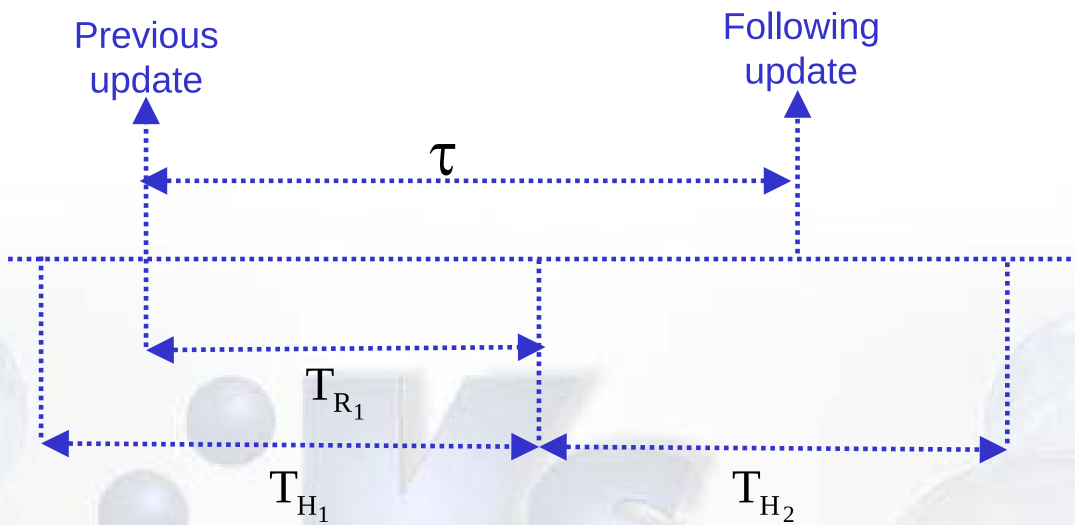
$$r_R(T_{R_i}) = \frac{[1 - F_H[T_{H_i}]]}{E[T_{H_i}]} \quad (8)$$

Optimal Time Threshold Calculation (4)

Calculation of v(1)

$$\begin{aligned} v(1) &= P[T_{R_1} > \tau] \\ &= 1 - P[T_{R_1} \le \tau] \\ &= 1 - R_{R_1}(\tau) \end{aligned} \qquad (9)$$

Optimal Time Threshold Calculation (5)



- I = 2, v(2) can be described as

$$v(2) = P[T_{R_1} < \tau] * P[T_{R_1} + T_{H_2} > \tau]$$
$$= P[T_{R_1} \le \tau] * [1 - P[T_{R_1} + T_{H_2} \le \tau]] \quad (10)$$

Optimal Time Threshold Calculation (6)

- General form of v(i)

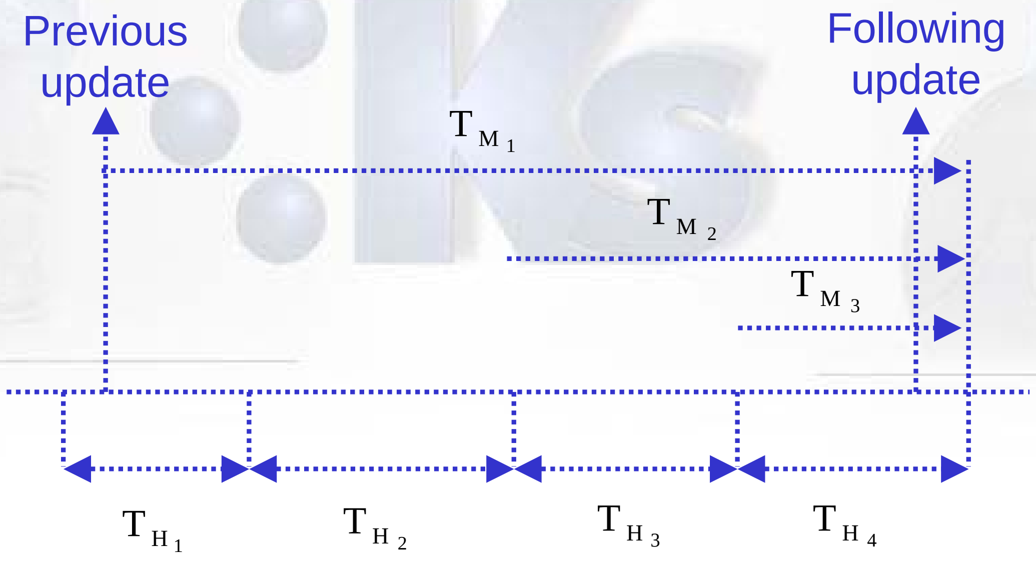
$$v(i) = \left[\prod_{n=1}^{i-1} P\left[\sum_{j=1}^{n} T_{H_j} \le \tau \right] \right] * \left[1 - P\left[\left(\sum_{j=1}^{i} T_{H_j} \right) \le \tau \right] \right] \qquad (11)$$

Remark $T_{H_1} = T_{R_1}$

Optimal Time Threshold Calculation (7)

- Derivation of forwarding pointer maintaining time

$$C_M = M * \left[\frac{T_{Life}}{\tau}\right] * \left[\sum_{i=1}^{\infty} v(i) * \left[E[T_{R_1}] + \sum_{j=0}^{i-1} j * E[T_{H_{j+1}}]\right]\right]$$



Optimal Time Threshold Calculation (8)

$$T_{M_1} = E[T_{R_1} + T_{H_2} + T_{H_3} + T_{H_4}]$$
$$T_{M_2} = E[T_{H_3} + T_{H_4}]$$
$$T_{M_3} = E[T_{H_4}]$$

$$T_{M_1} = E[T_{R_1}] + E[T_{H_2}] + E[T_{H_3}] + E[T_{H_4}]$$
$$T_{M_2} = E[T_{H_3}] + E[T_{H_4}]$$
$$T_{M_3} = E[T_{H_4}]$$

$$\text{Total Time} = E[T_{R_1}] + E[T_{H_2}] + 2*E[T_{H_3}] + 3*E[T_{H_4}]$$

When i =4

$$\left[E[T_{R_1}] + \sum_{j=0}^{i-1} j * E[T_{H_{j+1}}] \right]$$

Optimal Time Threshold Calculation (9)

$$T\_Cost(\tau) = U * \left[\frac{T_{Life}}{\tau}\right] + M * \left[\frac{T_{Life}}{\tau}\right] * \left[\sum_{i=1}^{\infty} v(i) * \left[E[T_{R_1}] + \sum_{j=0}^{i-1} j * E[T_{H_{j+1}}]\right]\right]$$

- Parameter initiation:U, M, T_{life} and Probability density of host residence time.

U = accounts for bandwidth utilization and computation requirement

M = memory usage

Optimal Time Threshold Calculation (10)

- Probability density of HRT is exponential distribution.

$$f_H(T_{H_i}) = \lambda \exp(-\lambda T_{H_i}) \qquad T_{H_i} \geq 0$$
$$= 0 \qquad T_{H_i} < 0$$

- Calculation of failure test (λ) using probability plotting. Assume to be $\lambda = 0.1$

- T_{life} can be estimated by multiplication of total number of visited host with average host residence time

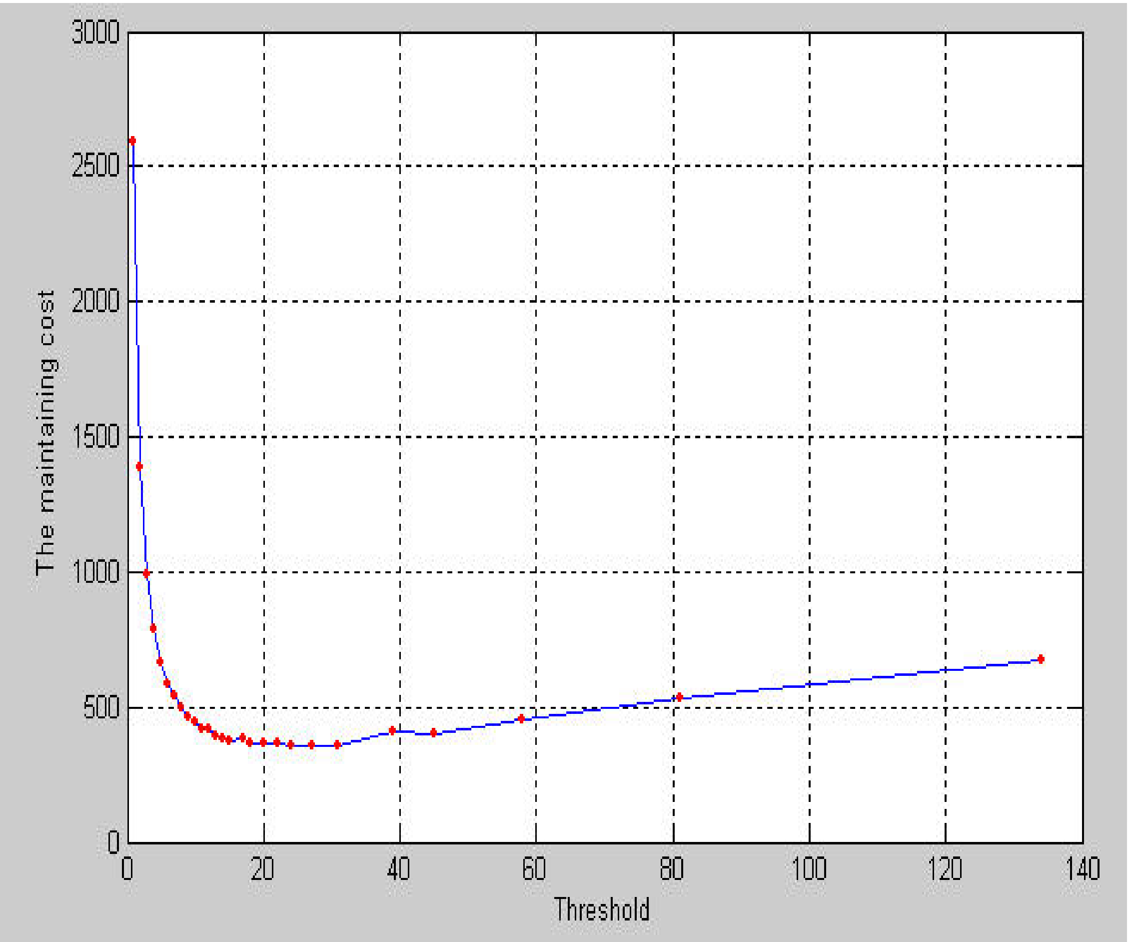
Simulation (1)

Simulation Parameters

- T_{life}= 200
- λ = 0.1
- U = 2
- M =1
- max nums of visted host = 15

Simulation Result

- τ_{opt} = 24
- τ = 24,27,31 can be used awell



Location update and Stale Location info

Location update: performed by mobile agent

$$UL = ENC_{Cluster}\left[\left[R_N, \text{Remaining\_updates}\right], \left[Sig_{host}(\text{kernel}, \text{host\_addr}\right]\right] \quad (12)$$

Stale location information:

a host retrieves an agent´s location shortly before the agent performs its following update.

$$\text{Cluster} \xrightarrow{\text{Message}} \text{Requestor}:$$

$$CL = ENC_{RH}[Sig_{Cluster}(R_N, \text{Owner's PublicKey}, \text{Kernel}, \text{Location}, \text{Remaining time to update})]$$

Summary

- Naming service architecture
- Server selection and load balancing
- Load distribution
- Secure name resolution
- Optimal time threshold calculation

Thank you for your attention

Questions........