The Cost of Learning Fast with Reinforcement Learning for Edge Cache Allocation

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Antoine LAVIGNOTTE

Nessim OUSSEDIK

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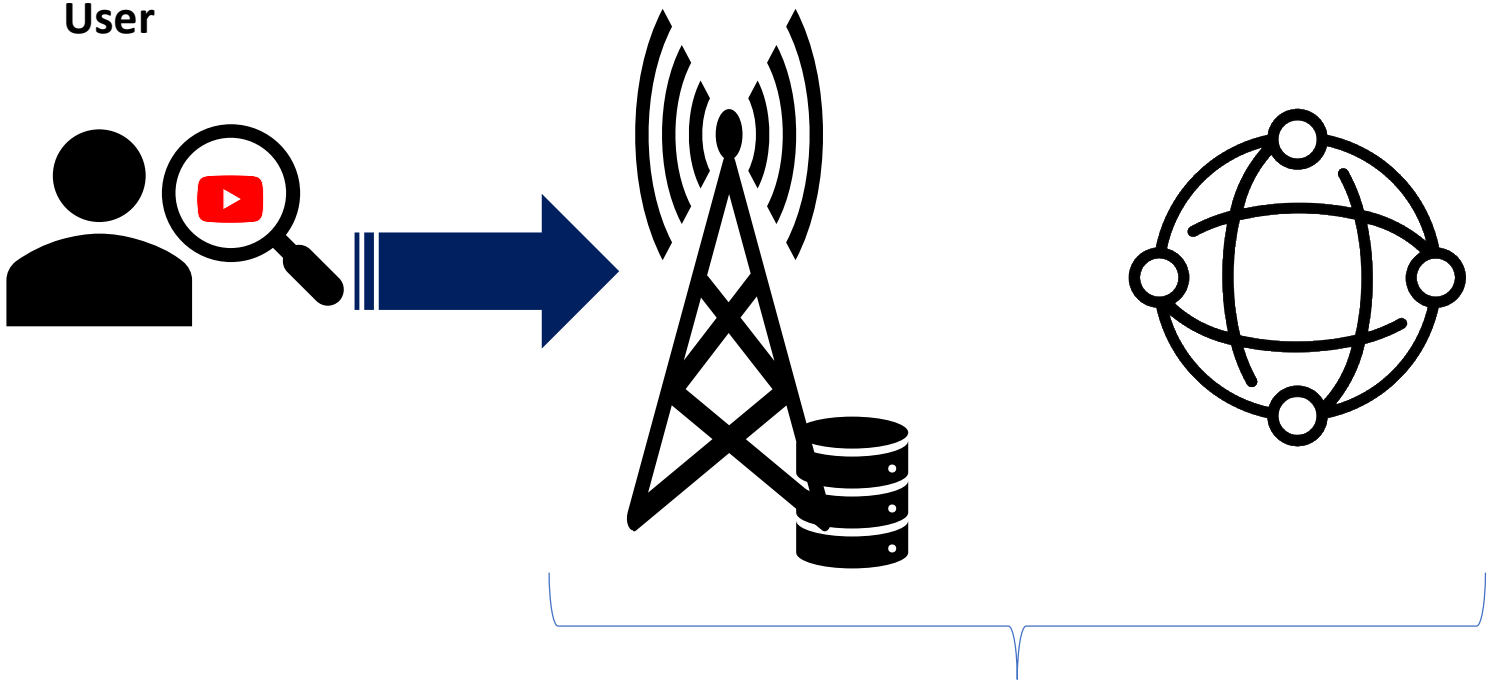
Context

Content Providers (CP) Servers

Edge structure
(e.g. Base Stations)

User

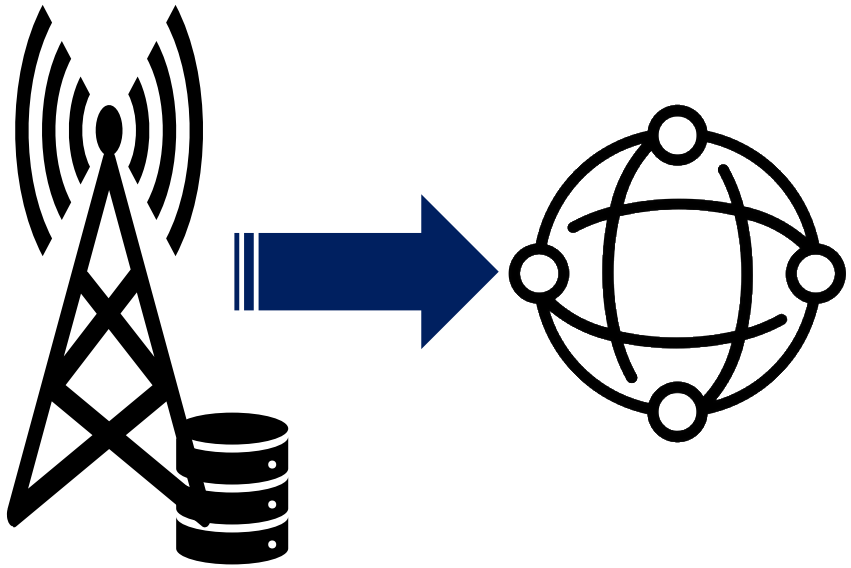


Managed by **Network Operators**

Context

User

Edge structure
(e.g. Base Stations)



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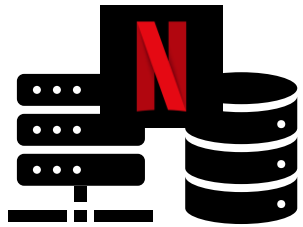
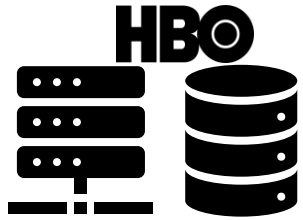
Content Providers (CP) Servers





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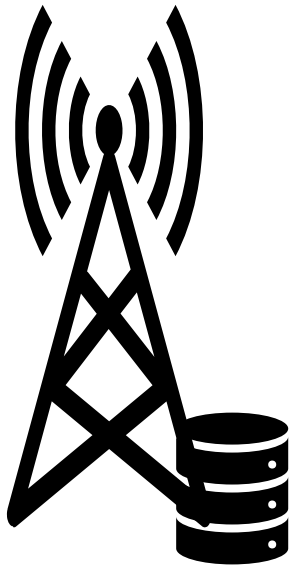

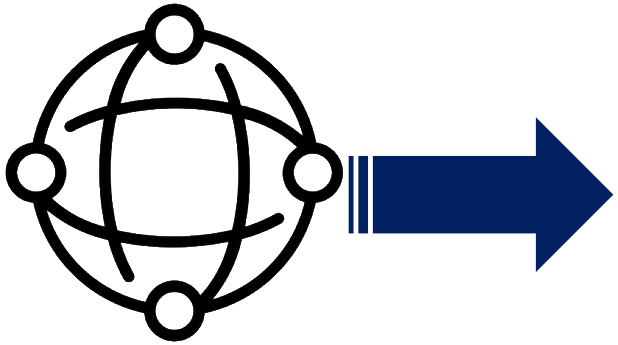

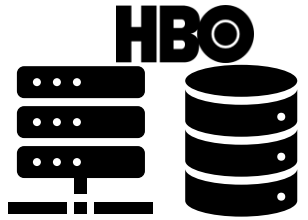

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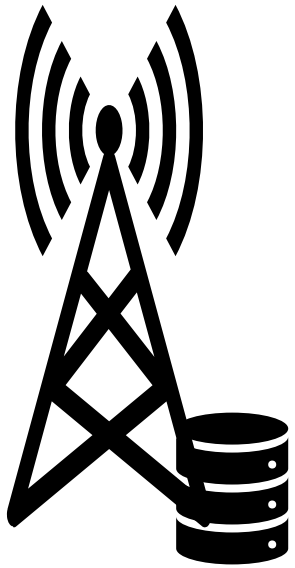
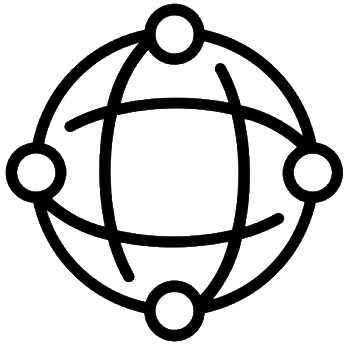
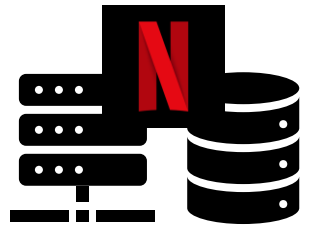
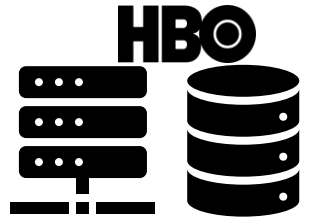






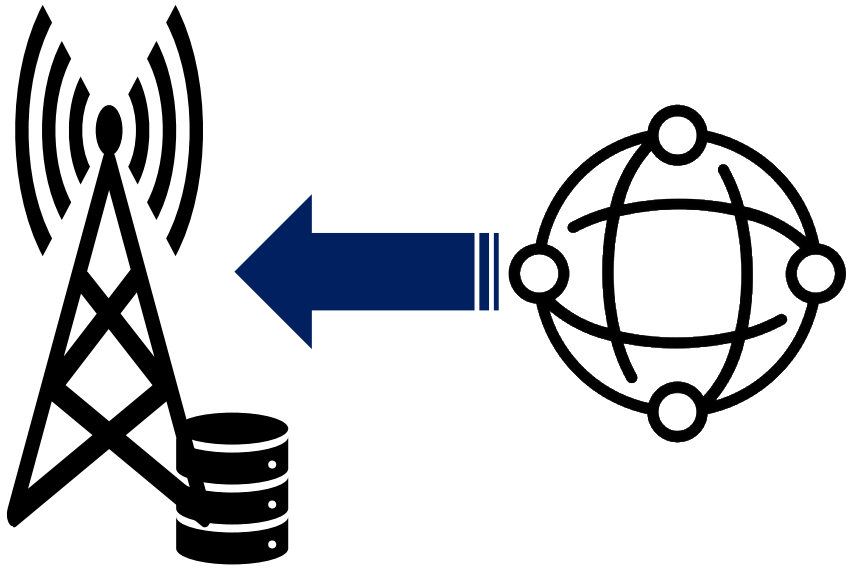


Managed by **Network Operators**

Context

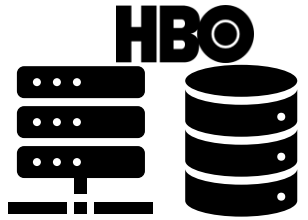
User

Edge structure
(e.g. Base Stations)



Managed by **Network Operators**

Content Providers (CP) Servers



Context

Content Providers (CP) Servers

Edge structure
(e.g. Base Stations)

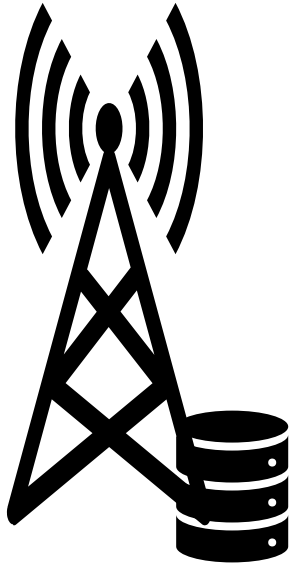
User

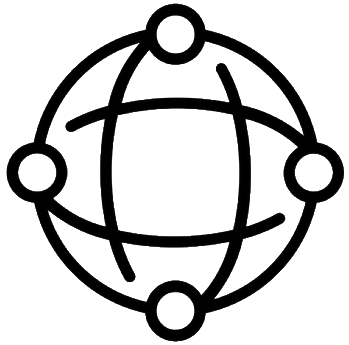
Managed by **Network Operators**

Context

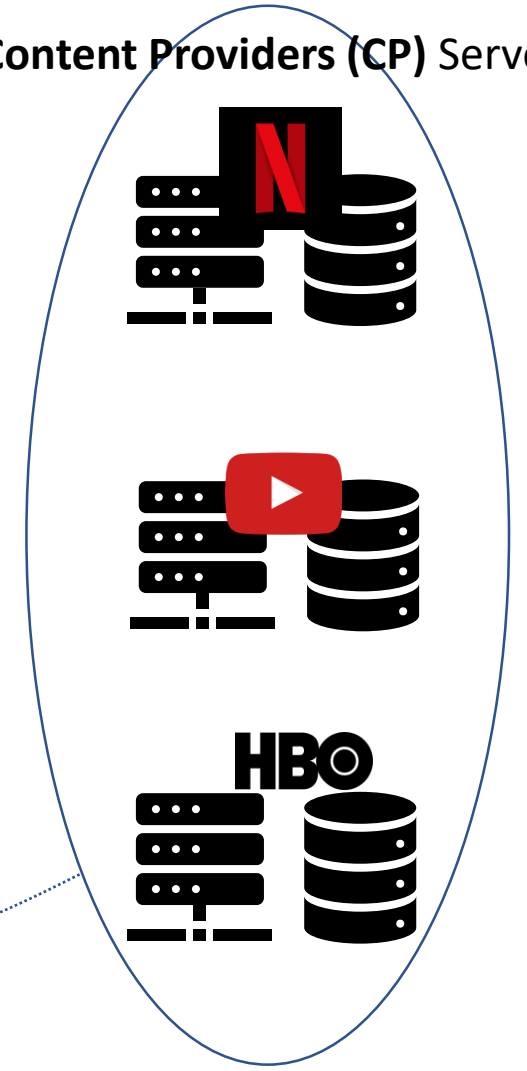
User

Edge structure
(e.g. Base Stations)



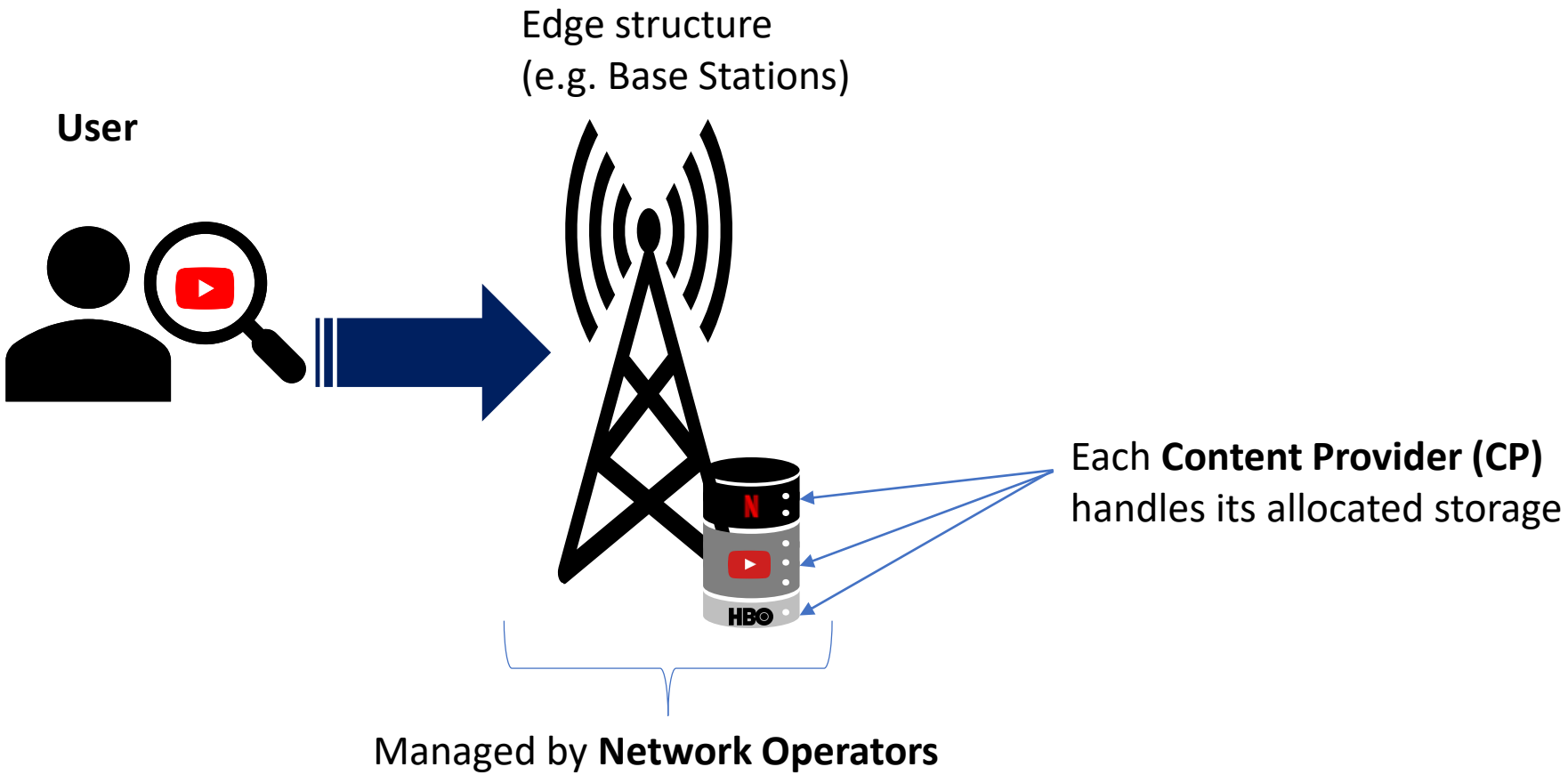


Content Providers (CP) Servers

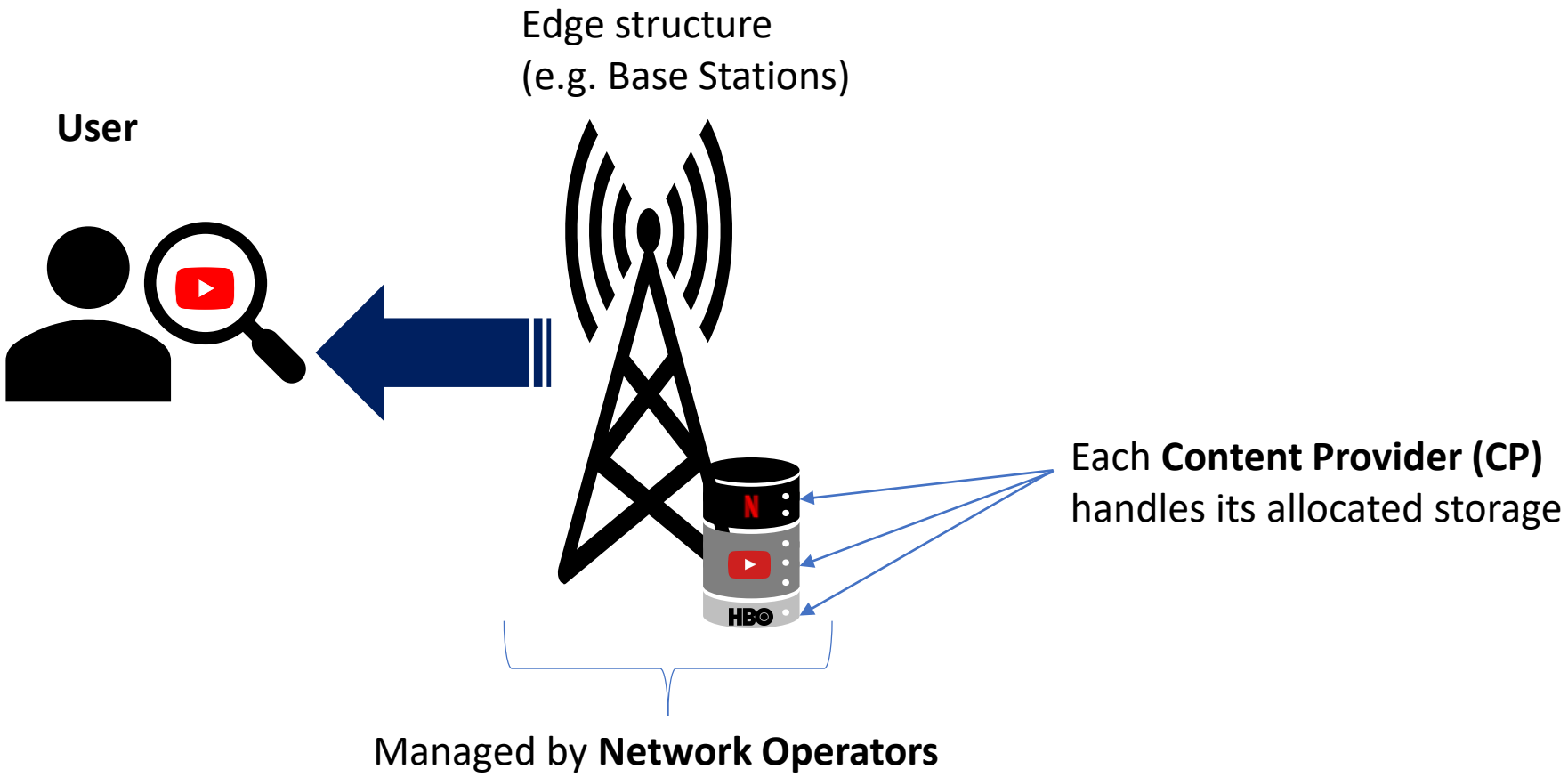


Managed by **Network Operators**

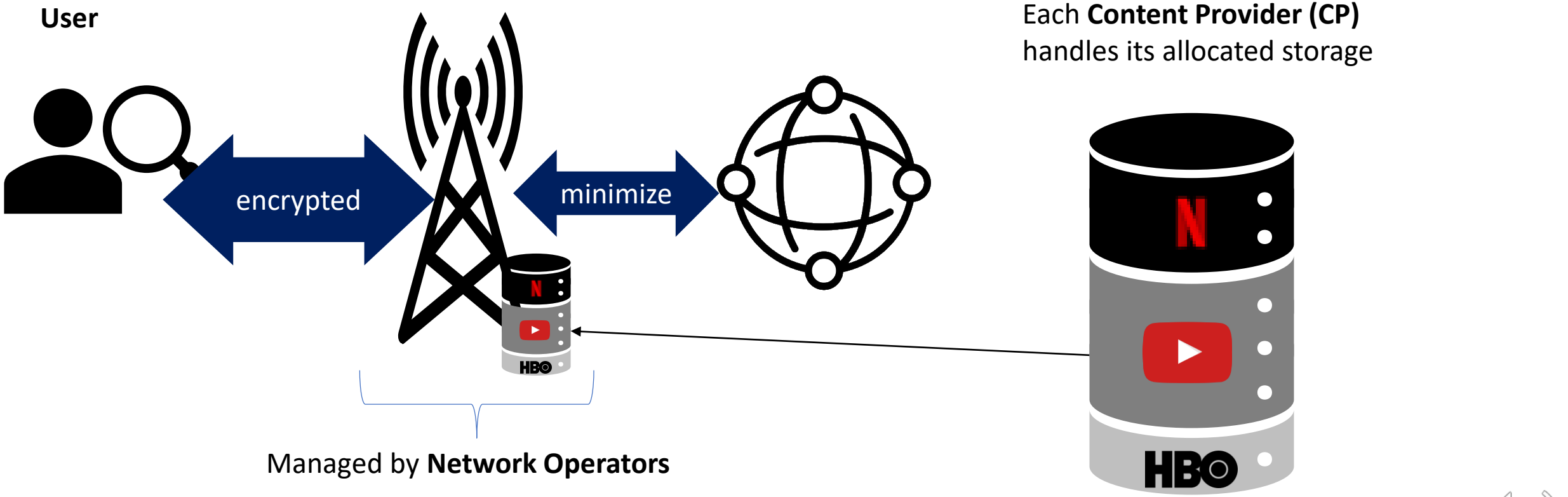
Context


Edge structure
(e.g. Base Stations)
User
Each **Content Provider (CP)**
handles its allocated storage
Managed by **Network Operators**

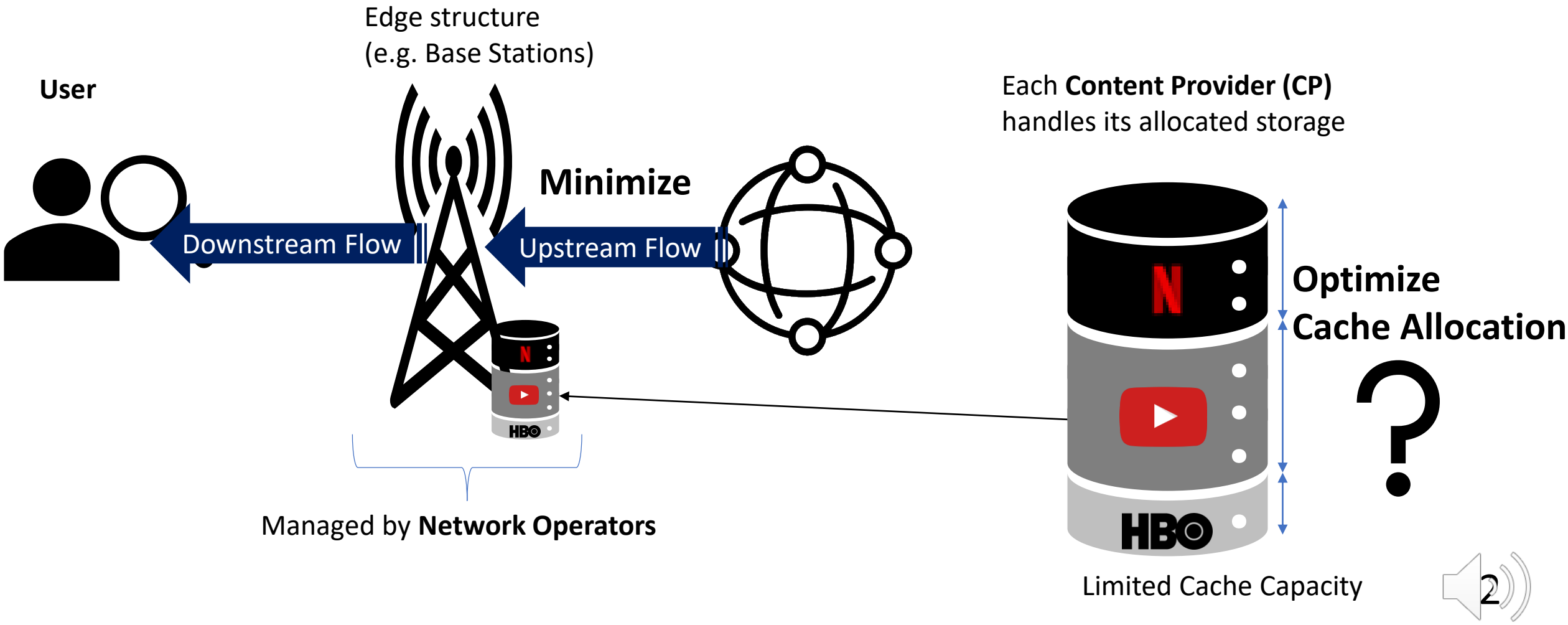
Context


Edge structure
(e.g. Base Stations)
User
Each **Content Provider (CP)**
handles its allocated storage
Managed by **Network Operators**

Problem


User
encrypted
minimize
Each **Content Provider (CP)** handles its allocated storage
Managed by **Network Operators**
Limited Cache Capacity

Problem


Edge structure
(e.g. Base Stations)
User
Each **Content Provider (CP)**
handles its allocated storage
Minimize
Downstream Flow
Upstream Flow
Optimize
Cache Allocation
Managed by **Network Operators**
Limited Cache Capacity

Method : SARSA

Catalogs: 10^6 videos for each Content Providers

Random initial allocation (state)

10^3 slots
(1 slot can contain 1 video)

Each second : Random Action

$C_N + \Delta$ slots

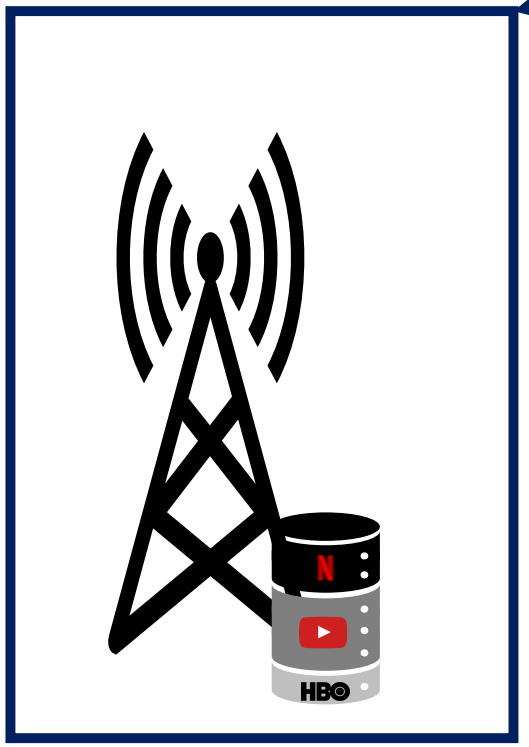
$C_Y - \Delta$ slots

C_H slots

Δ : the number of slots by which we perturb the cache allocation

Method : SARSA

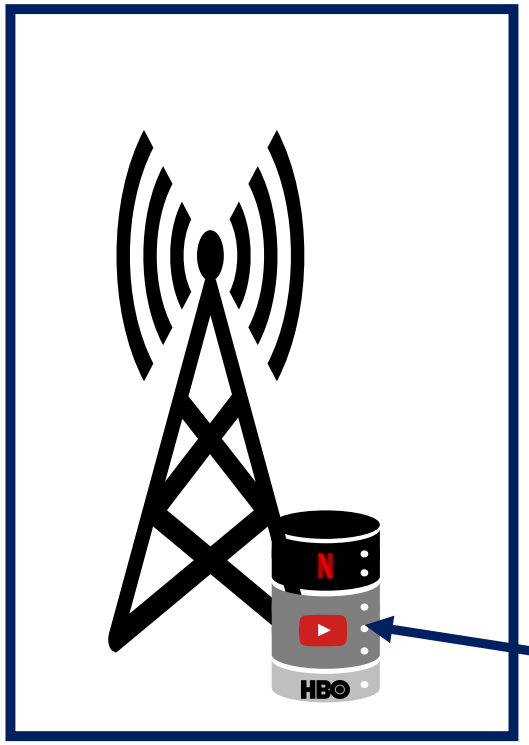
RL Agent updating Q-table
(RL= Reinforcement Learning)

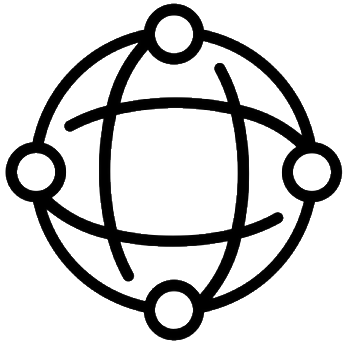


Q-table	Action $+\Delta$ to N $-\Delta$ to Y	Action $+\Delta$ to N $-\Delta$ to H	…
State (C_N; C_Y; C_H)	Expected cost		
State (C_N'; C_Y'; C_H')			
…			

Method : SARSA

Each seconds= 1 algorithm iteration

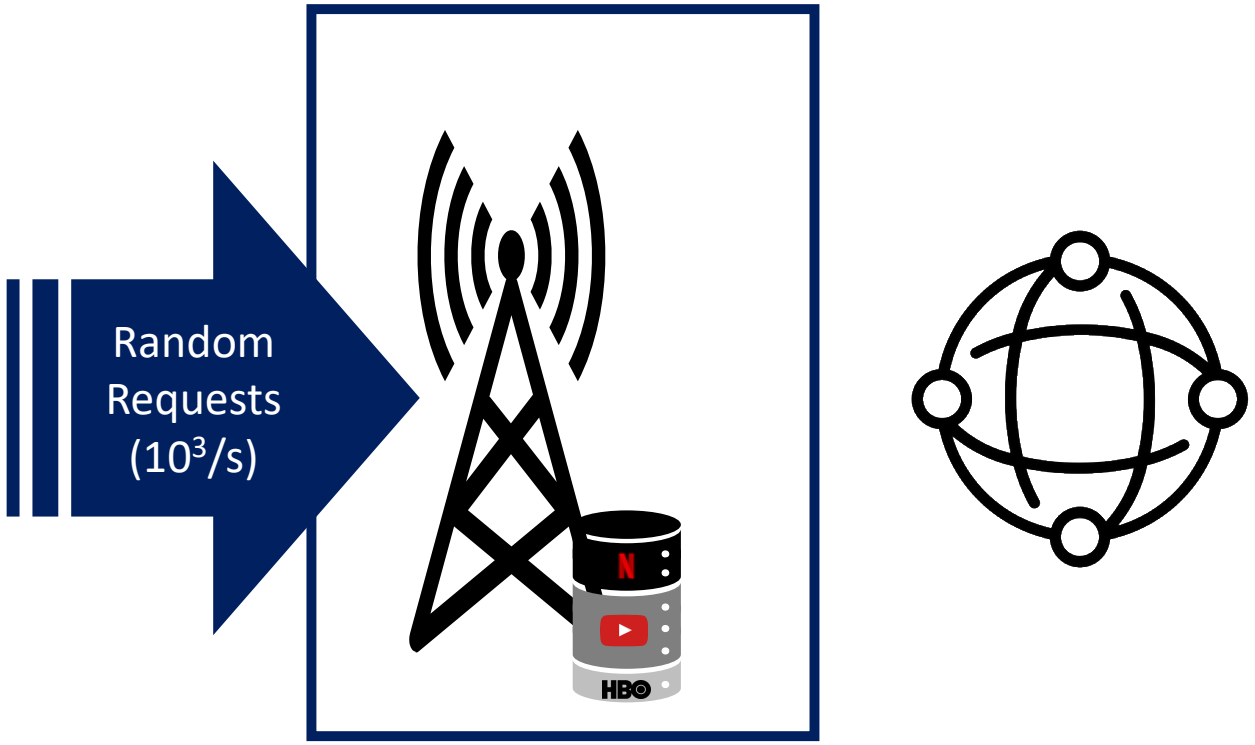




Probabilistically chosen perturbation
(based on epsilon-greedy policy)

Method : SARSA

Each seconds= 1 algorithm iteration



Method : SARSA

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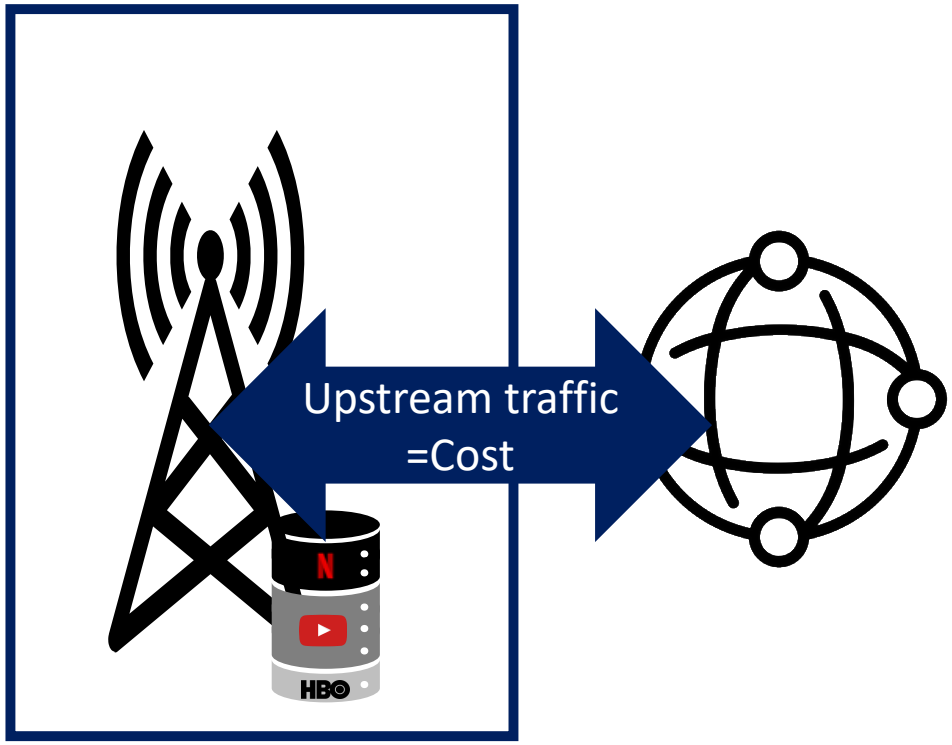

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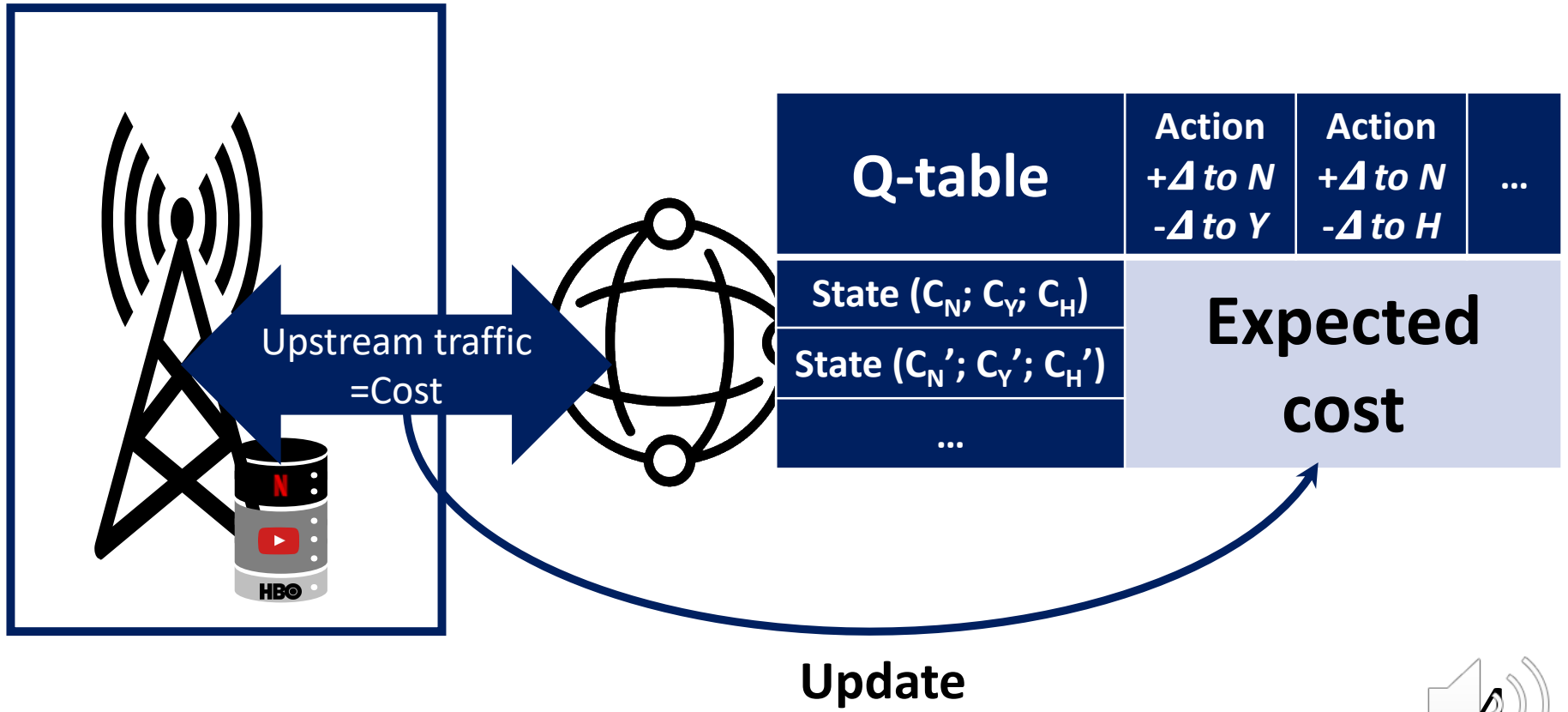
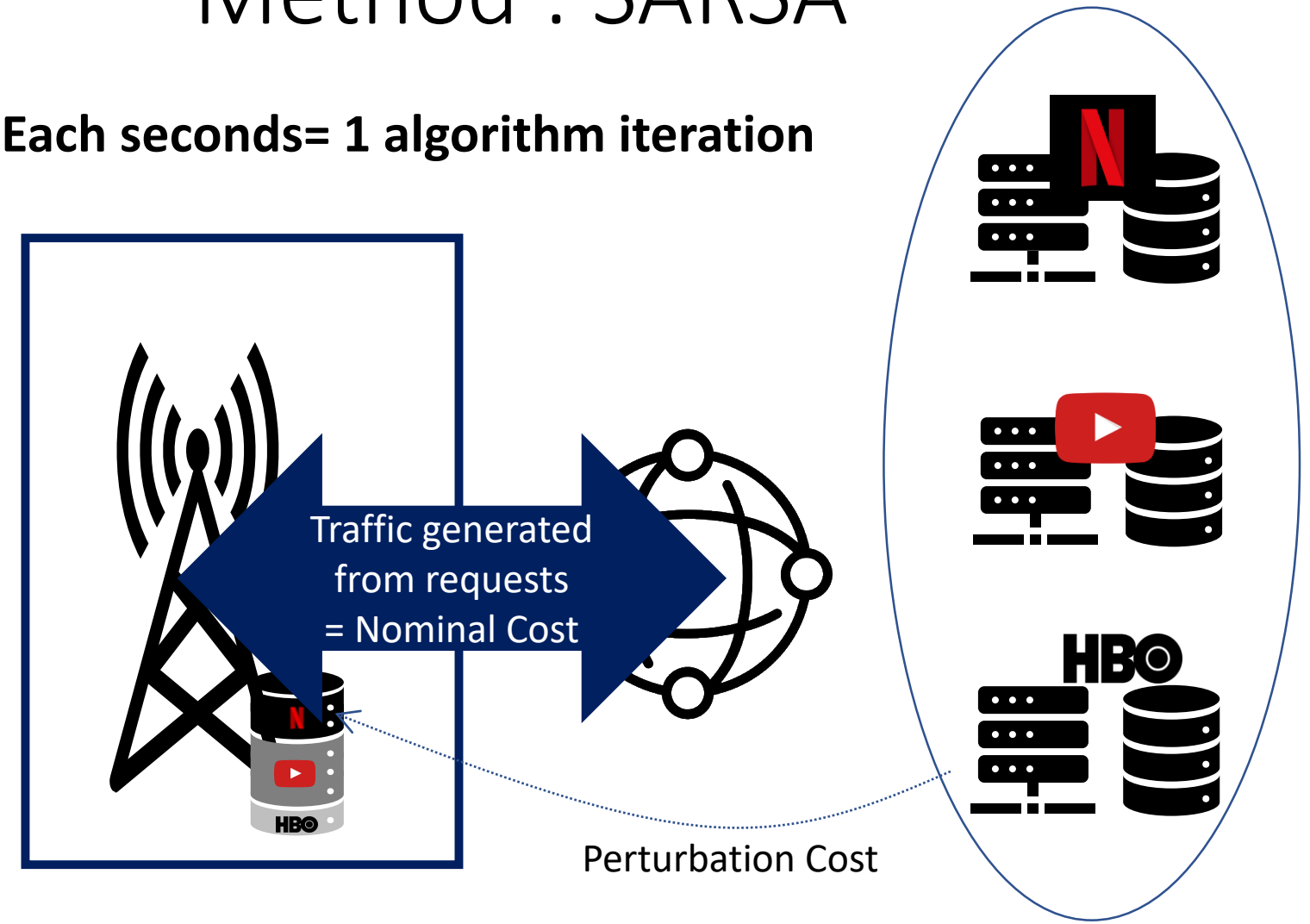


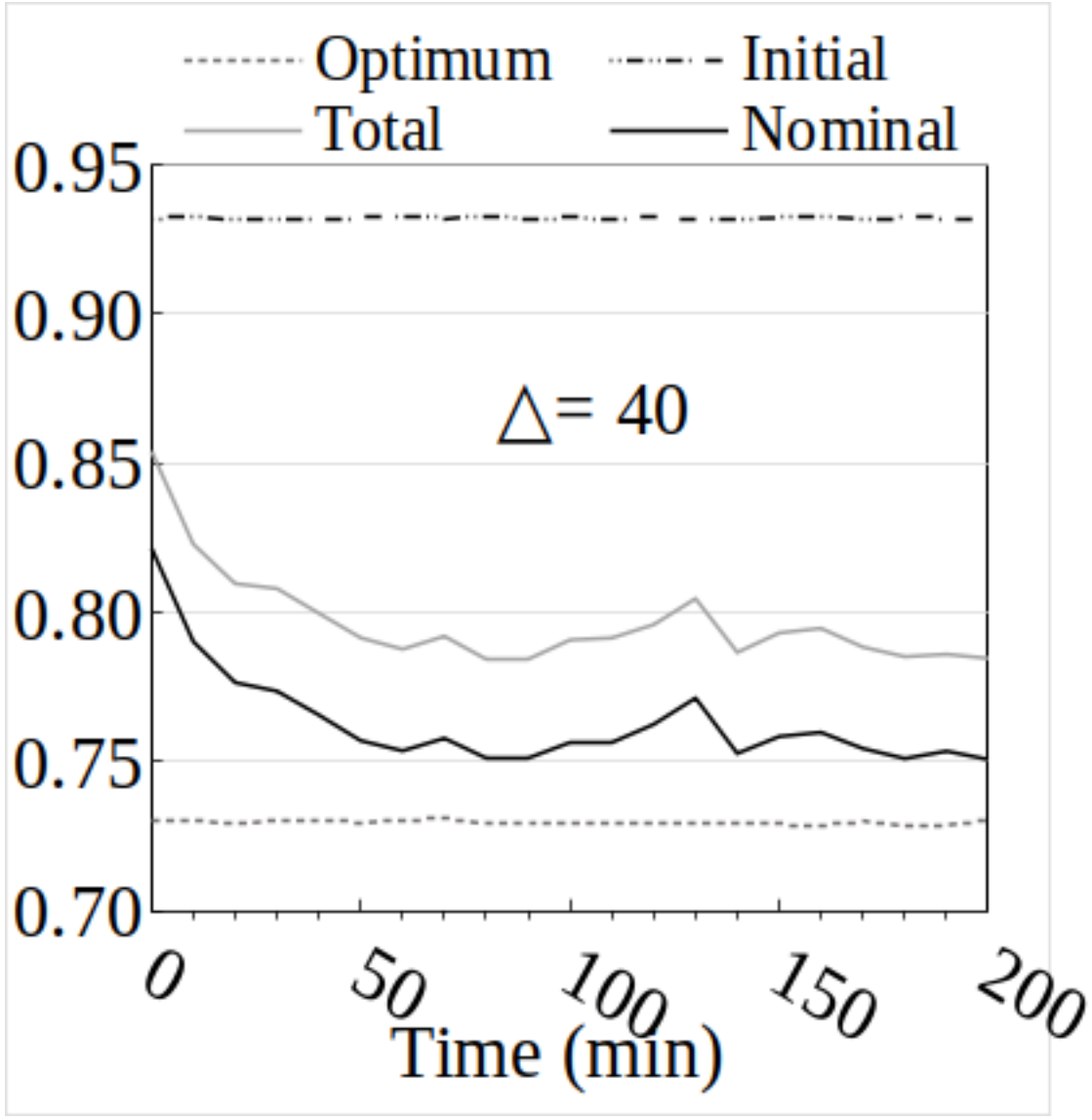
Method : SARSA

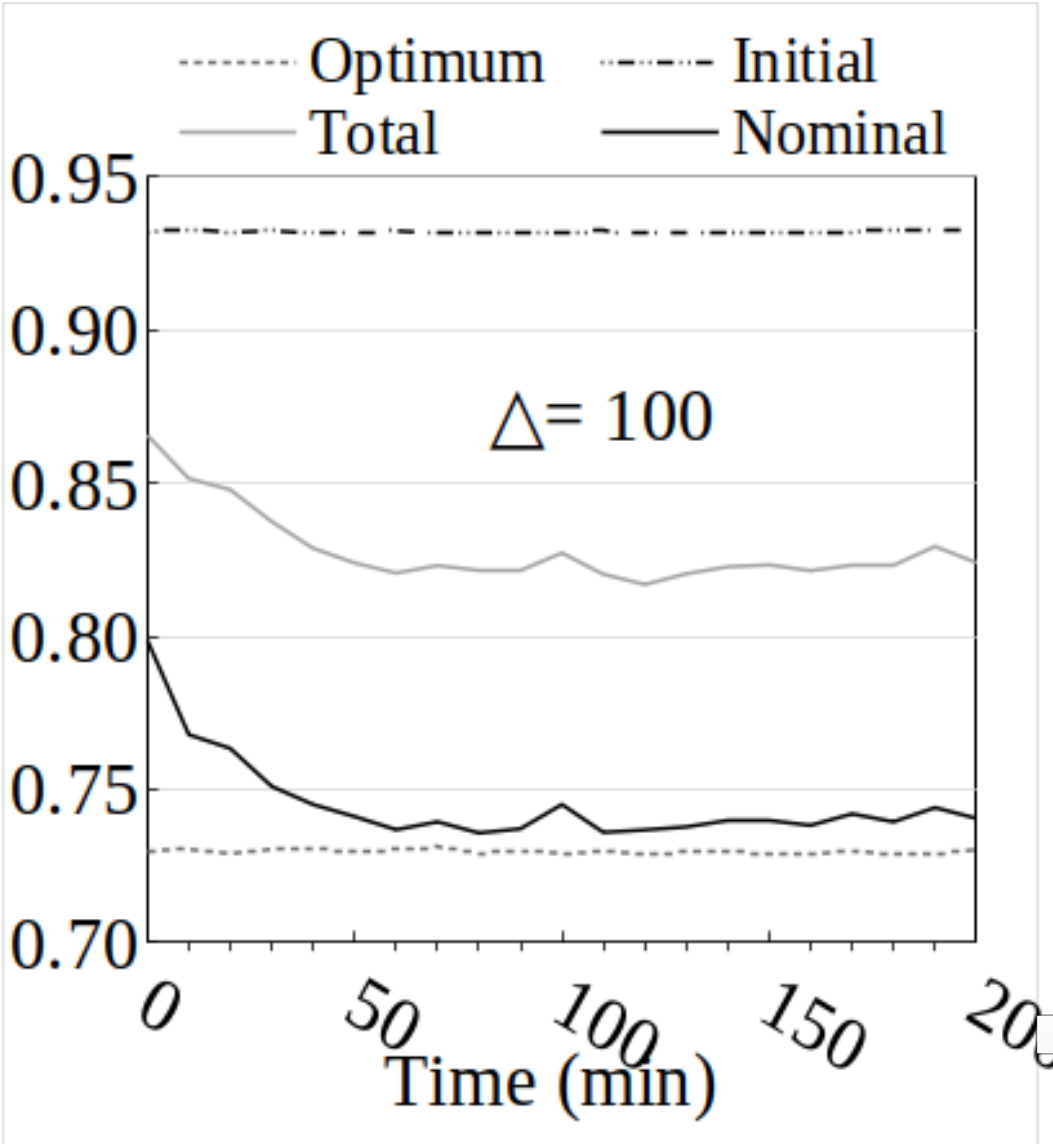
Each seconds= 1 algorithm iteration

Nominal Cost
+
Perturabtion Cost
=
Total Cost



Results : Costs over time





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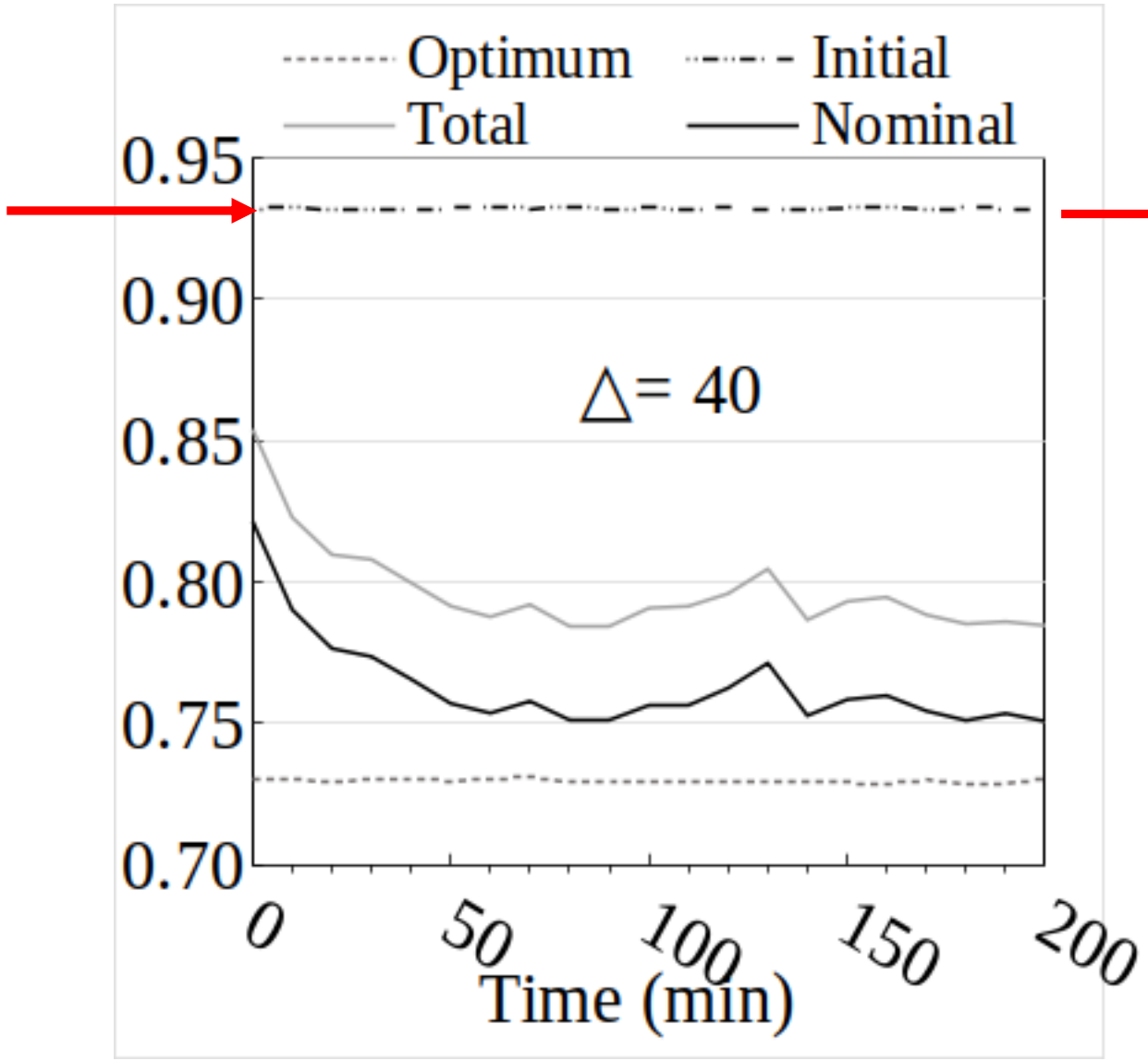

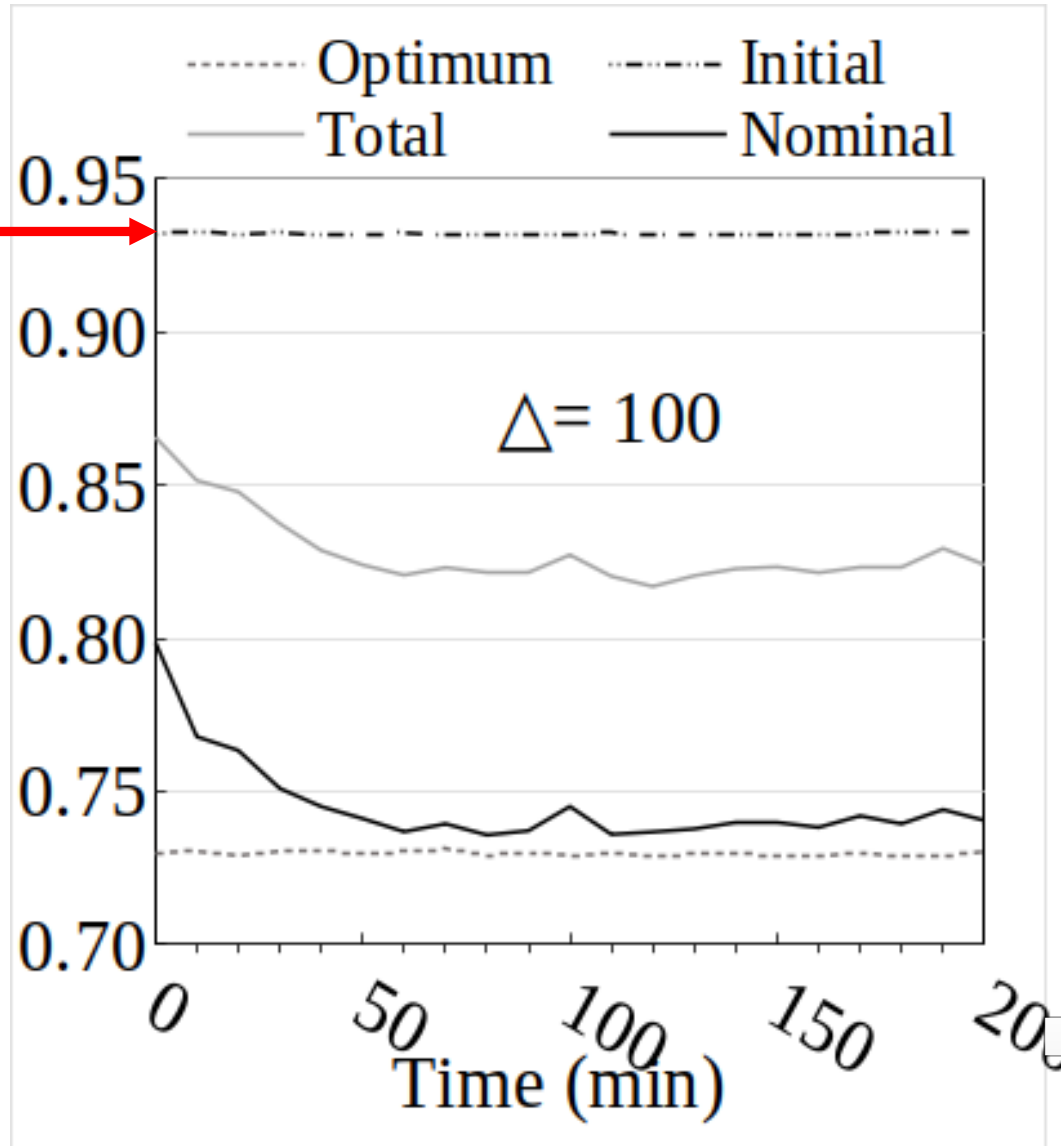

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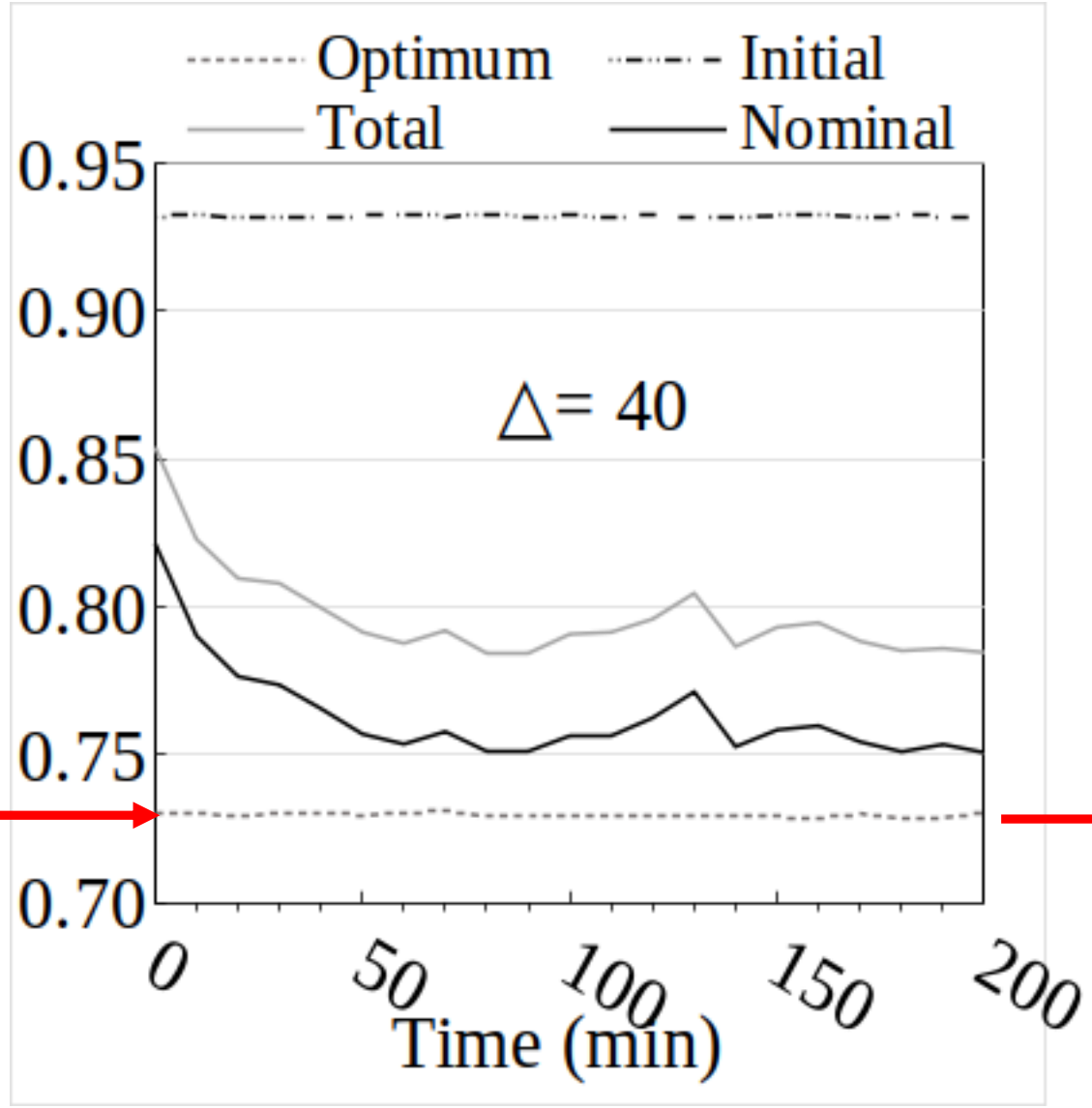

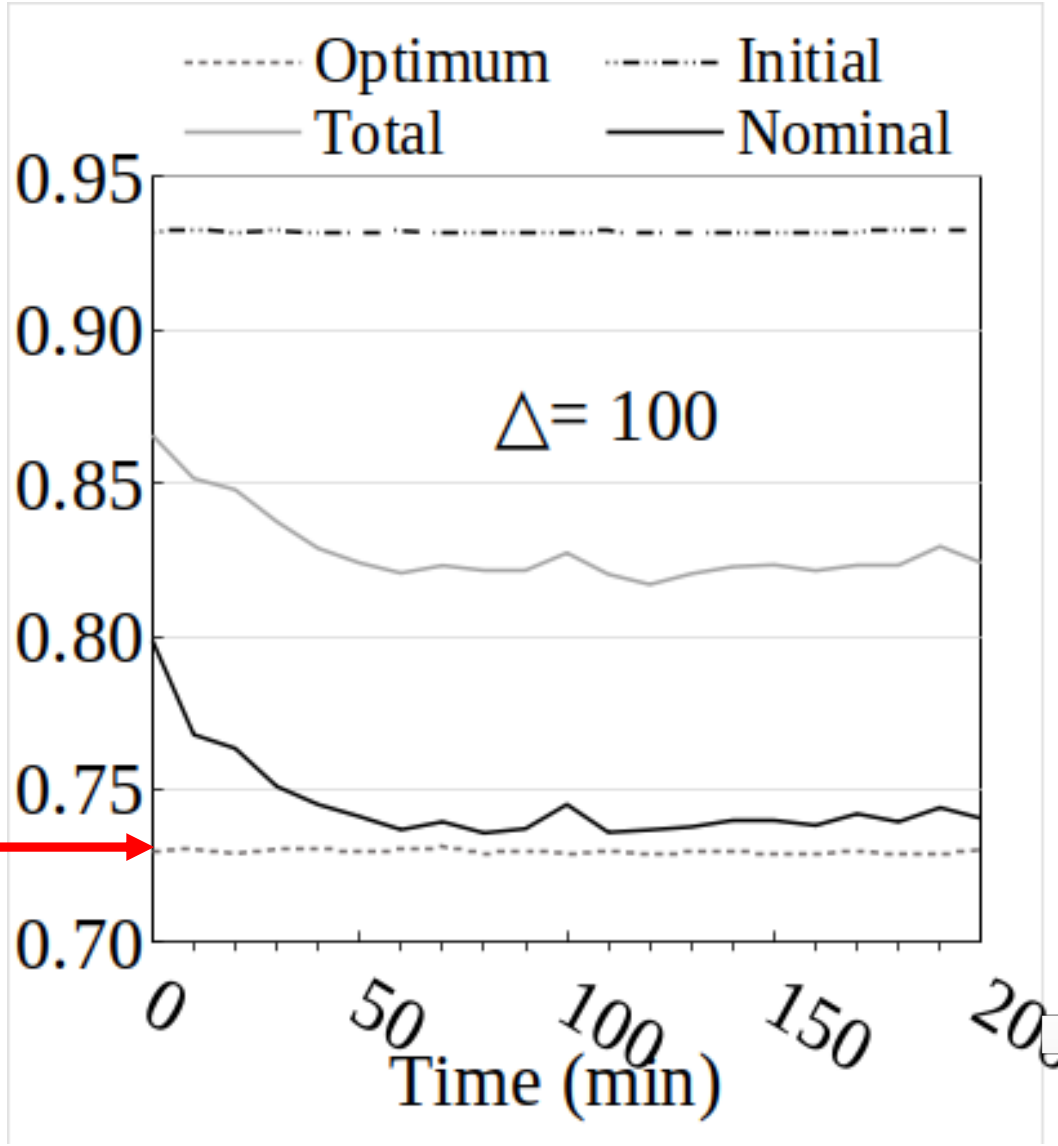

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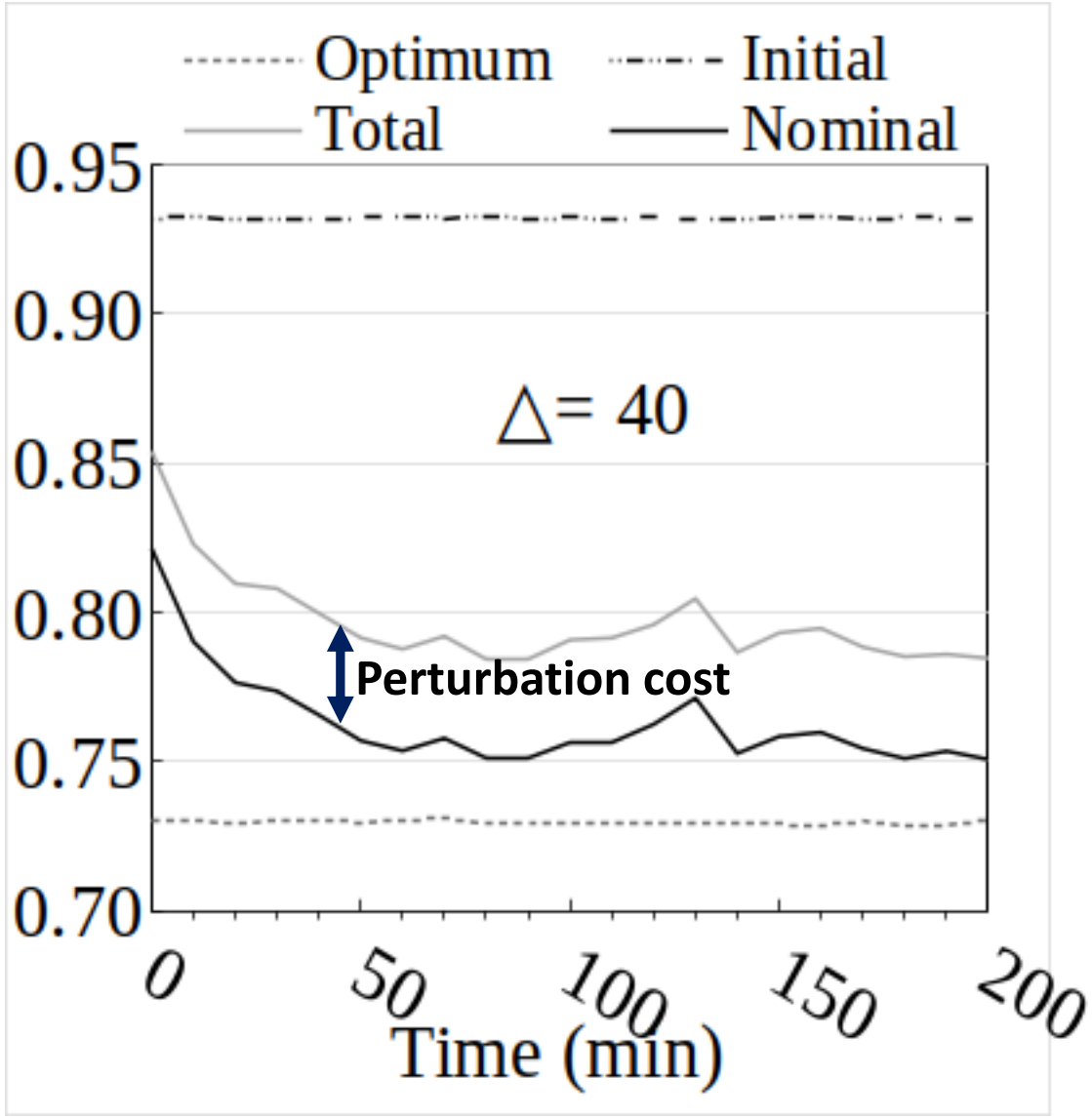

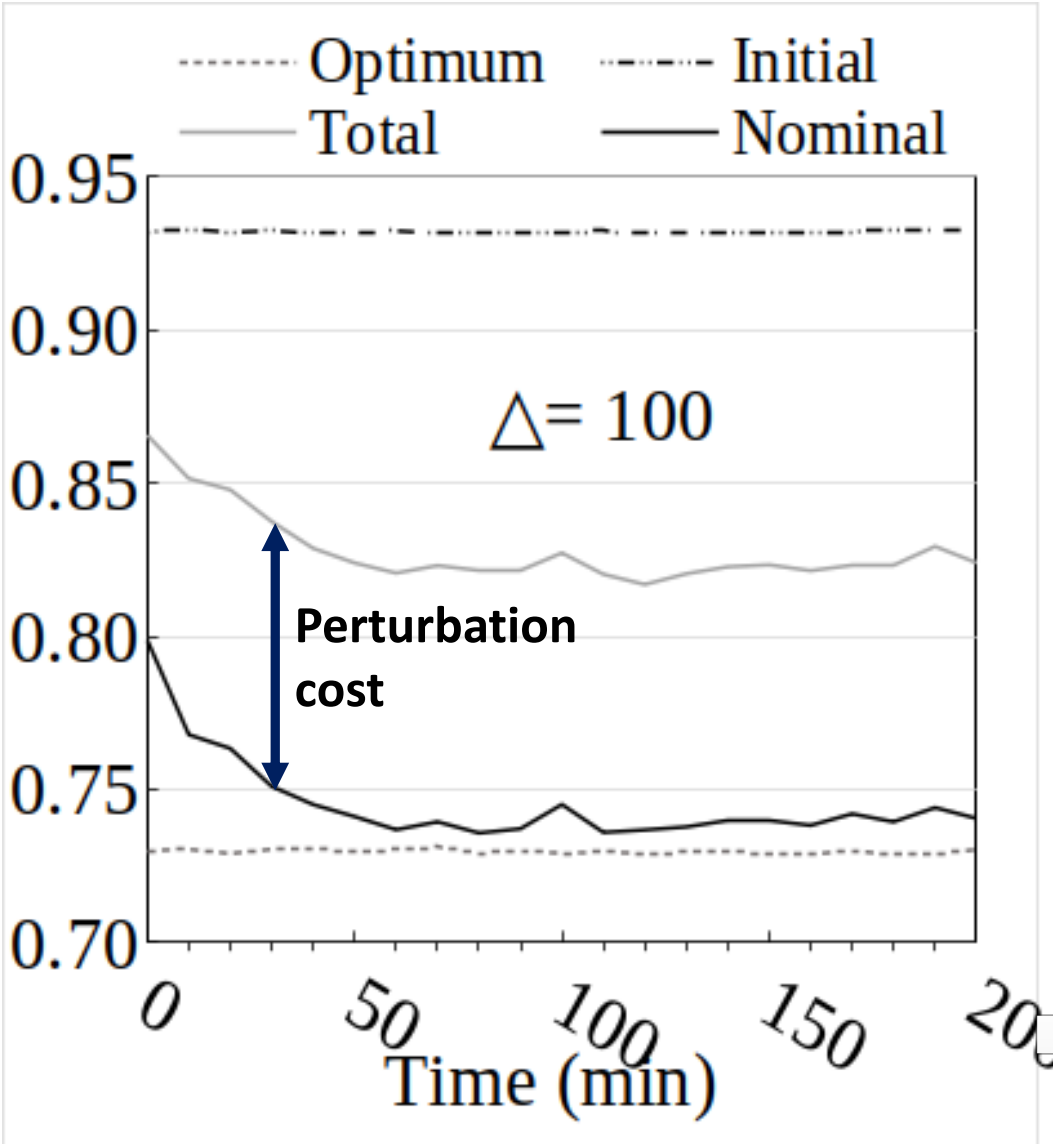

Conclusion

- A compromize must be found between learning faster and costing lesser.

Future Works:

- Comparison of our RL solution with Stochastic Optimization Solution*
- Study of non-stationnary systems (evolutions of requests loads and video's popularity)
- Study of more complex scenarios with CPU allocation and quality of experience indicators

*Araldo, A., Dán, G., & Rossi, D. (2018). Caching Encrypted Content via Stochastic Cache Partitioning. IEEE/ACM Transactions on Networking, 26(1), 548–561.