BENNS: A Surrogate Model for Hybrid Evolution of Service Function Chain Embeddings

Theviyanthan K.

Hello World! 👋

I am a third-year Ph.D. student, researching Genetic Algorithms for autonomous networks at the University of Glasgow.

Theviyanthan (Thivi) Krishnamohan

hello@thivi.dev

School of Computing Science,
University of Glasgow

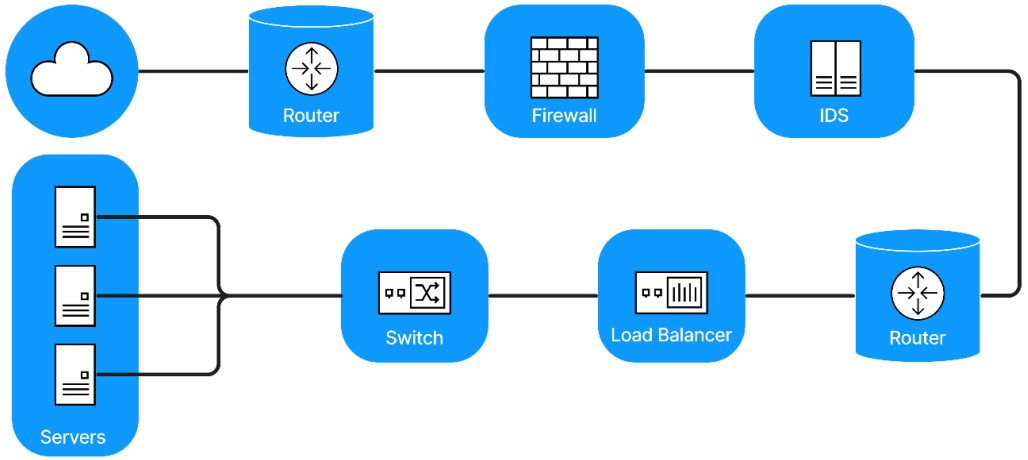
www.thivi.dev

Background

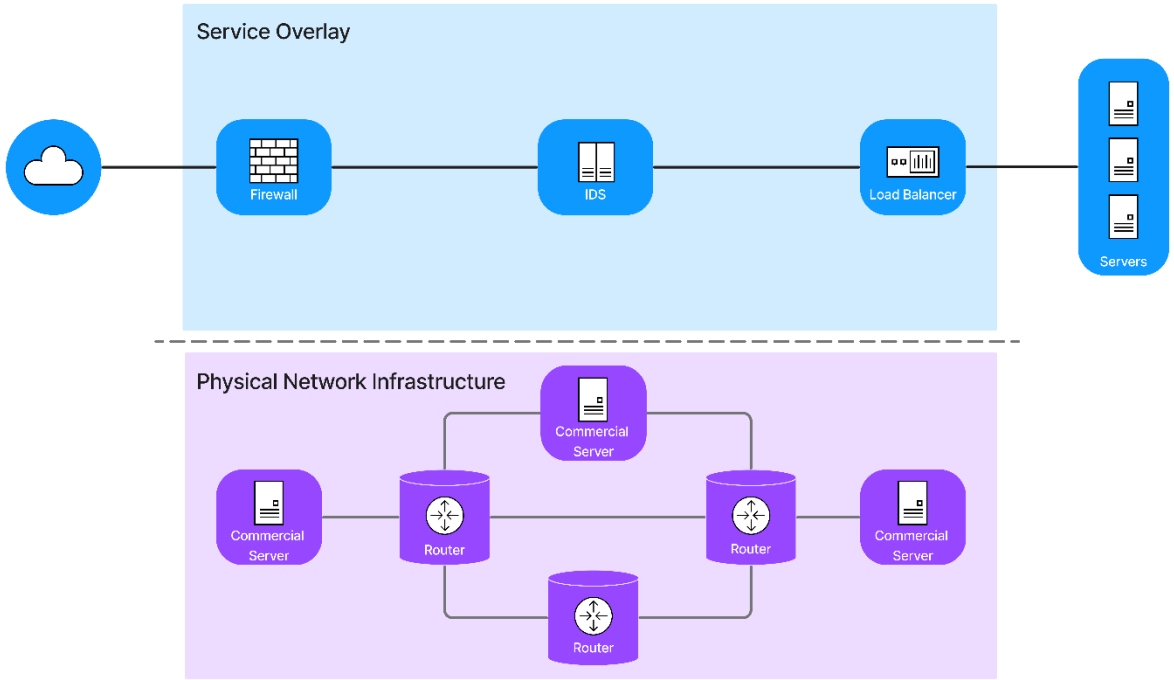
What are Service Function Chains (SFCs)?

- SFCs combine Network Function Virtualisation and Software-Defined Networking to create a service overlay over the physical network.

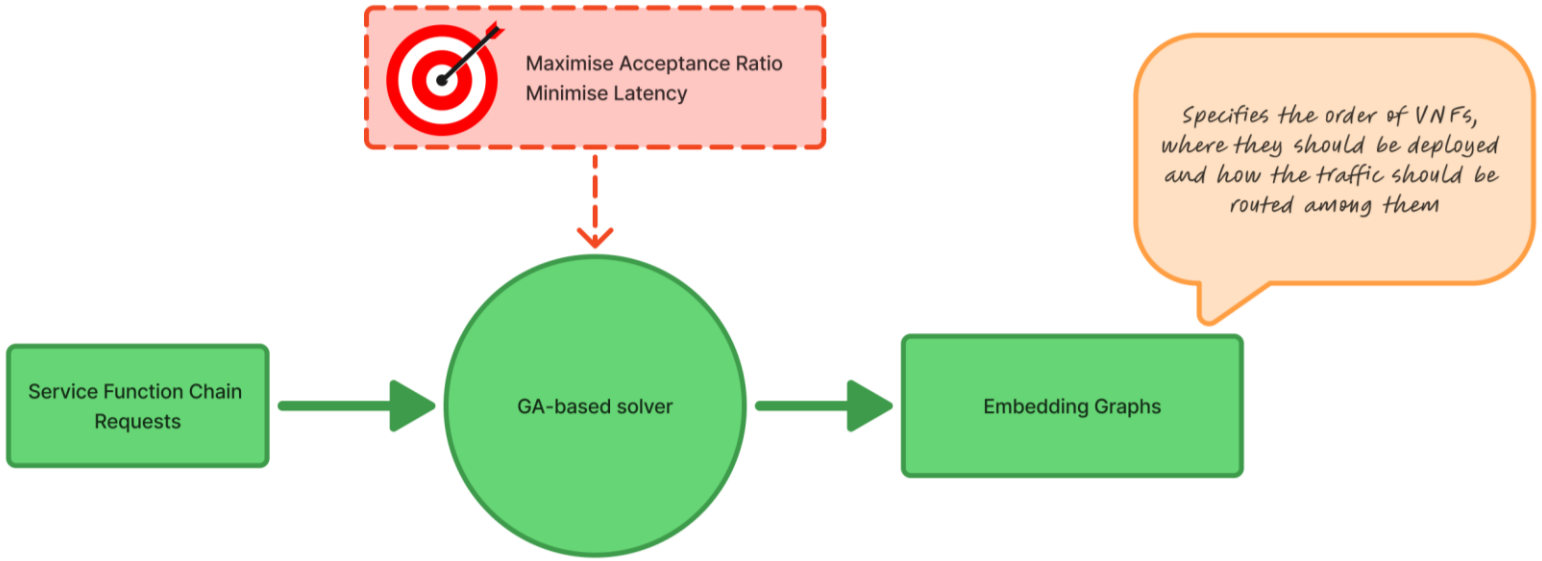
A traditional network:



A Service Function Chain:

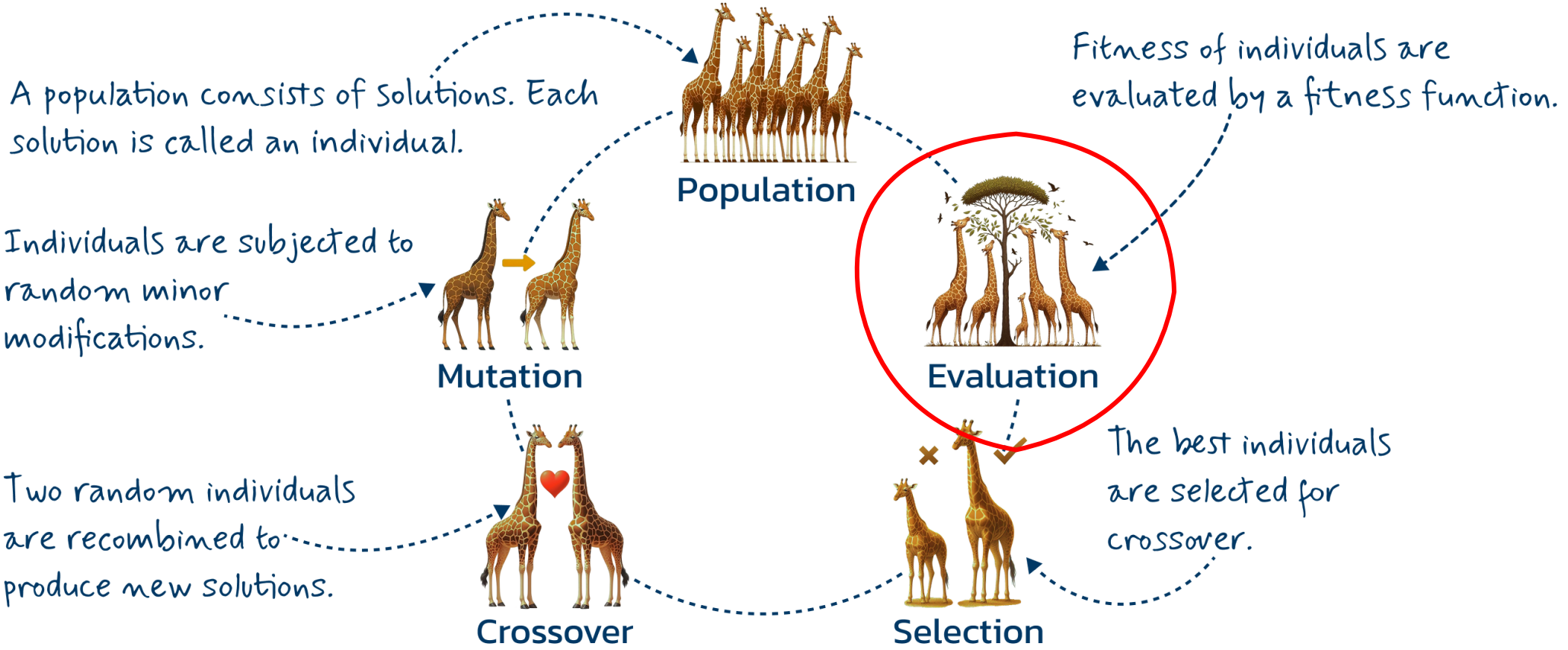


Problem Formulation



- **Maximise** Acceptance Ratio—the number of SFC Requests that can be accepted over the total number of SFC Requests received. **This can be mathematically computed**.
- **Minimise** Latency—the amount of time taken for traffic to traverse the SFC. **This has to be either measured experimentally or approximated using a model**.

Genetic Algorithms



Fitness Evaluation

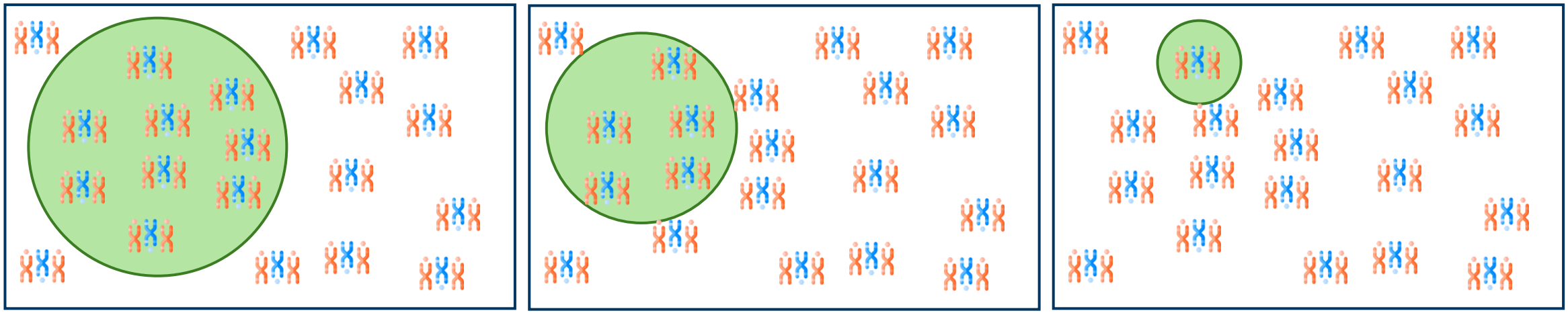
Online Evaluation	Offline Evaluation
Evaluation accuracy is high	Evaluation accuracy is low
Slower evaluation	Faster evaluation

- We use a hybrid evaluation approach, combining the speed of offline evaluation with the accuracy of online evaluation.
- For online evaluation, we use the **OpenRASE** emulator we developed for SFC embedding experiments.
- For offline evaluation, we use the **BENNS** model.

BENNS

Design Goals of BENNS

- Guide GA toward the optimal region of the search space by
  - Approximating traffic latency
  - Prioritising speed over accuracy
  - Using a simple predictive model



Factors Affecting Traffic Latency

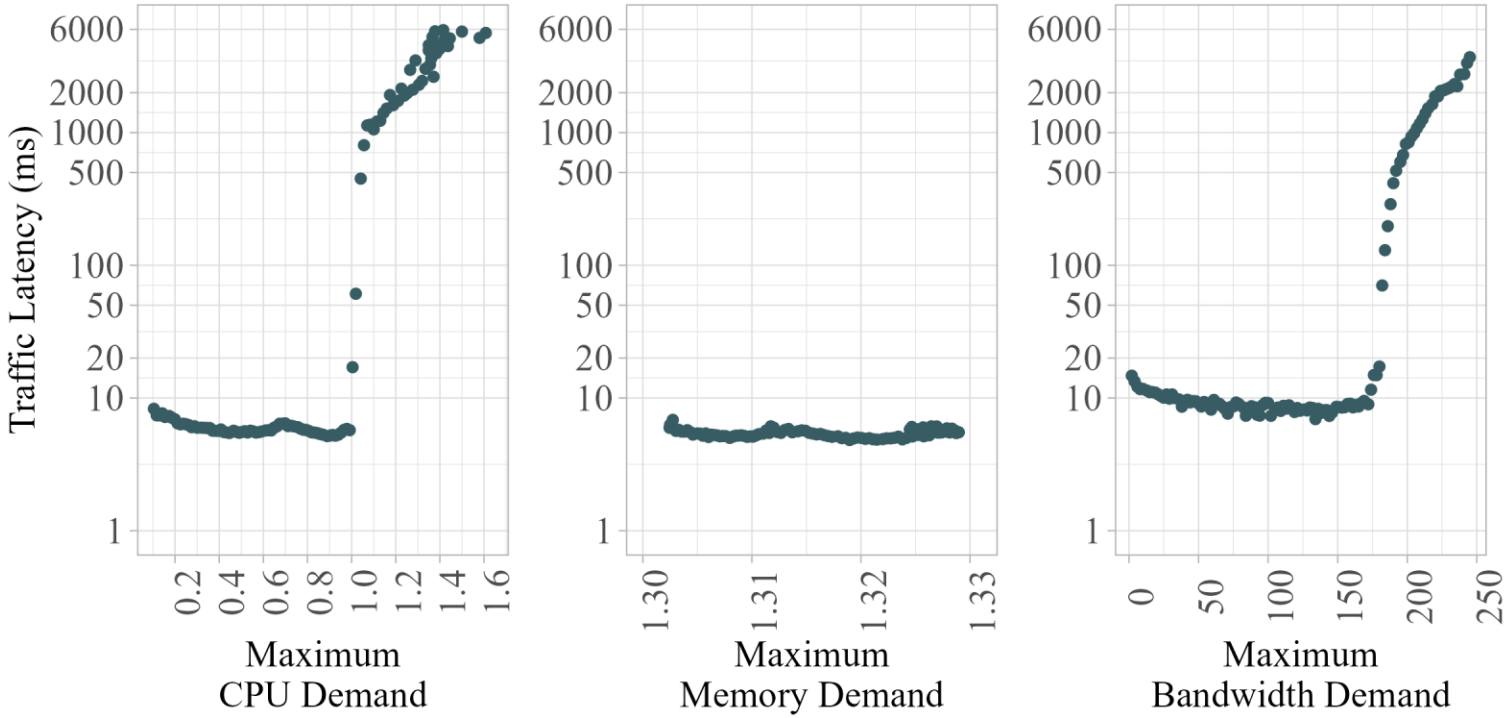
- CPU demand.
- Memory (RAM) demand.
- Bandwidth demand.

- Propagation delay of links.

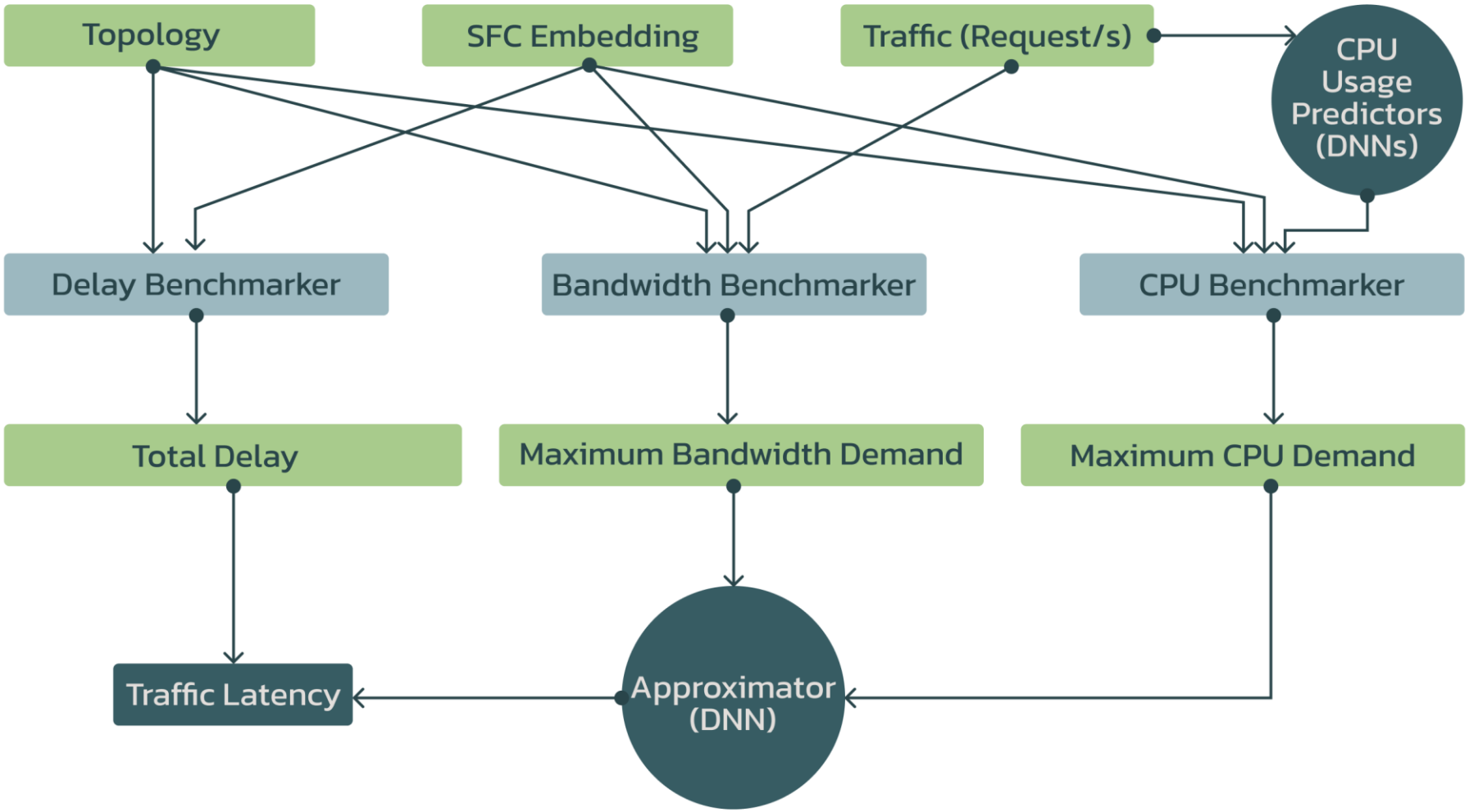
This is not exhaustive. But good enough for an approximation.

Empirical Analysis

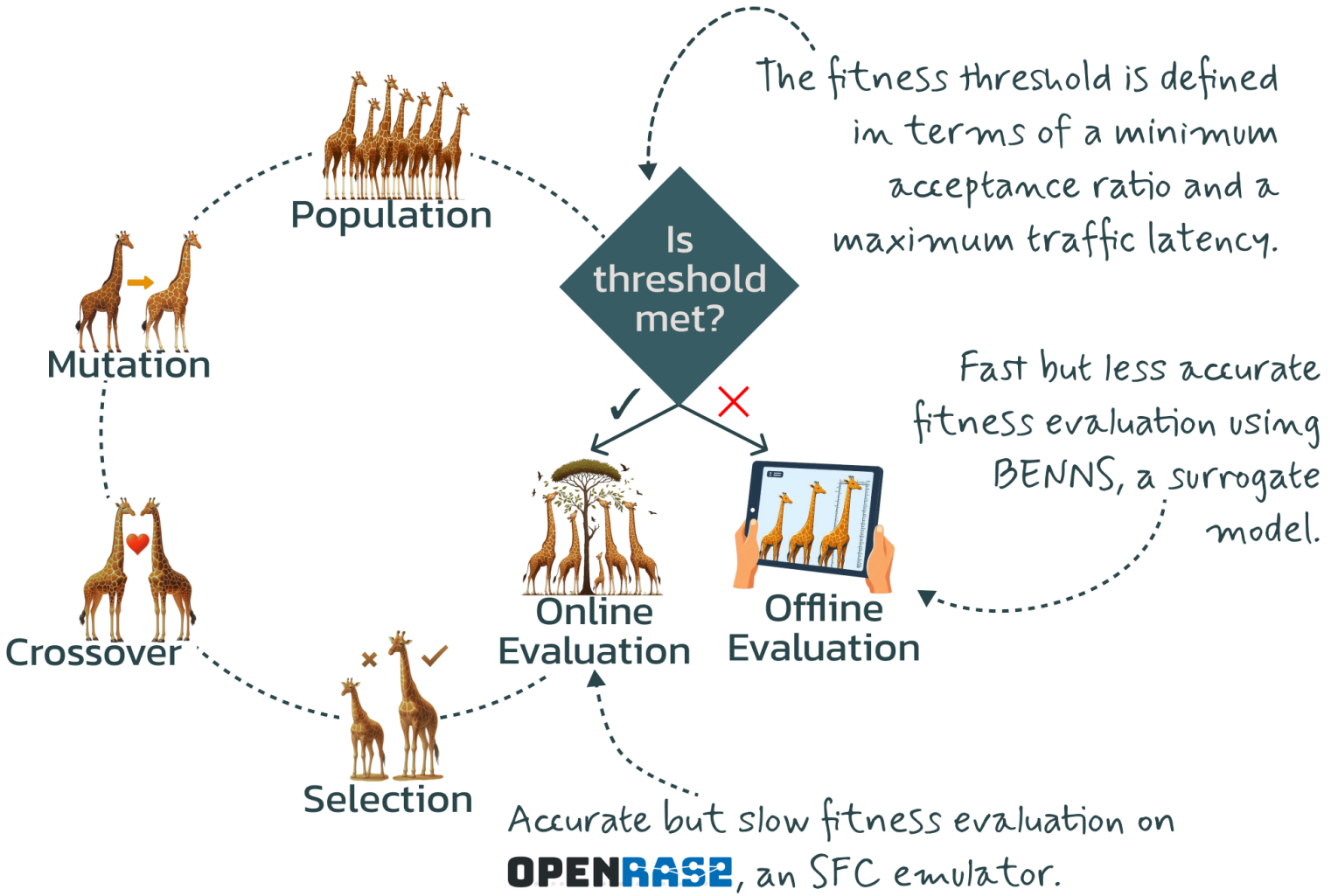
- We ran a toy experiment to empirically evaluate how these factors affect traffic latency.



BENNS Model

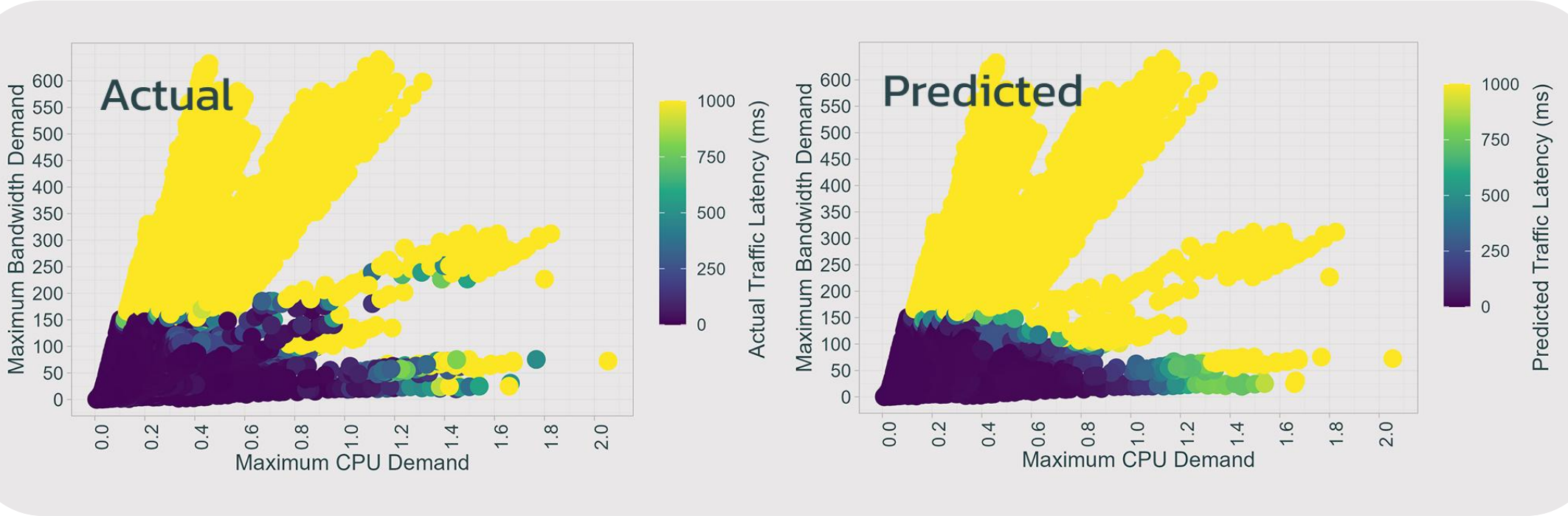

Topology
SFC Embedding
Traffic (Request/s)
CPU Usage Predictors (DNNs)
Delay Benchmarker
Bandwidth Benchmarker
CPU Benchmarker
Total Delay
Maximum Bandwidth Demand
Maximum CPU Demand
Traffic Latency
Approximator (DNN)

Hybrid Evolution



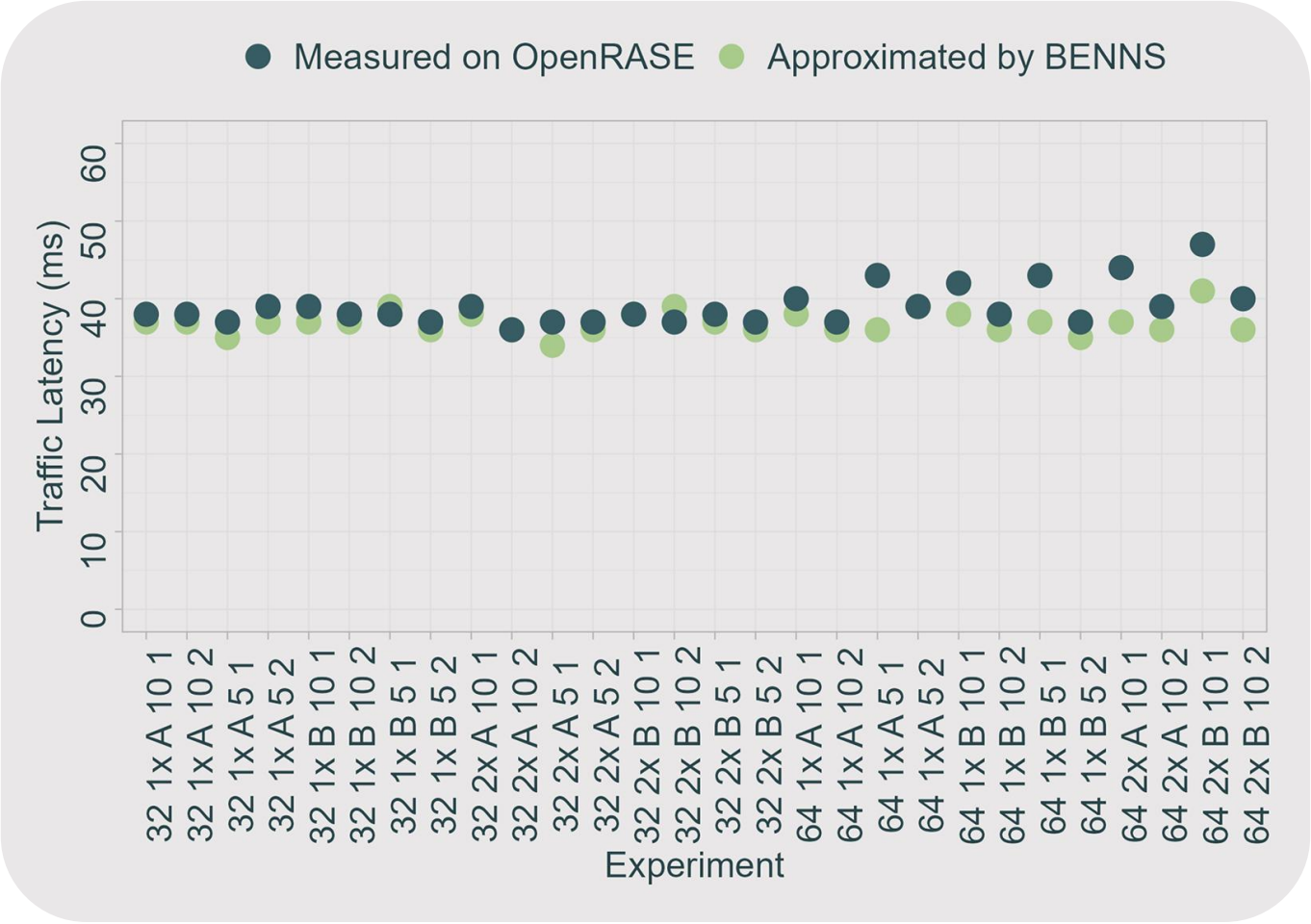
Results

Performance on Validation Dataset



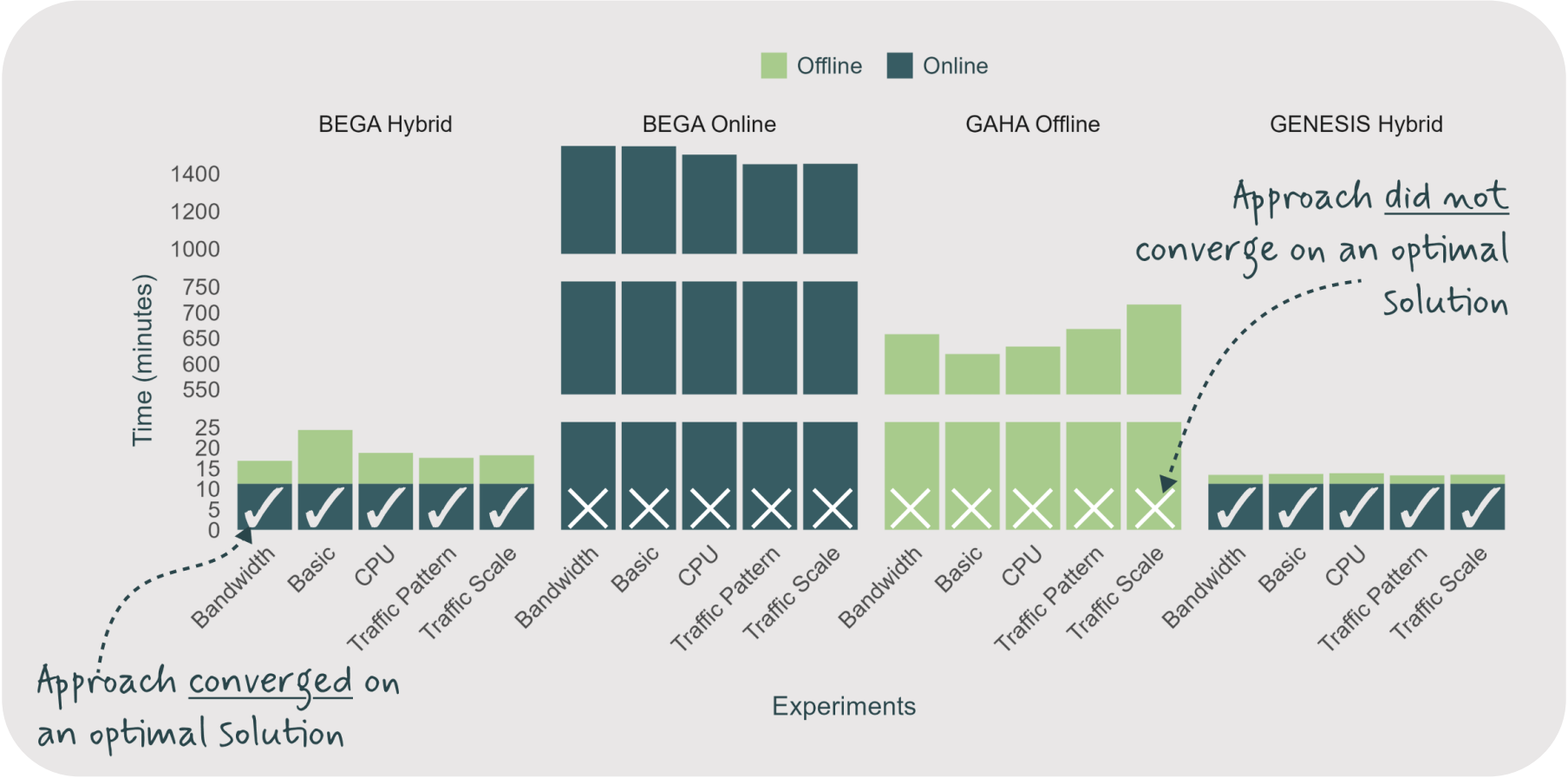
Approximation Accuracy

- We ran 28 experiments with different network configurations, comparing the traffic latency approximated by BENNS with the traffic latency measured on OpenRASE.



Evaluation of Hybrid Evolution

- We implemented our hybrid approach using BEGA and GENESIS, and compared it to an online-only and an offline-only approach.



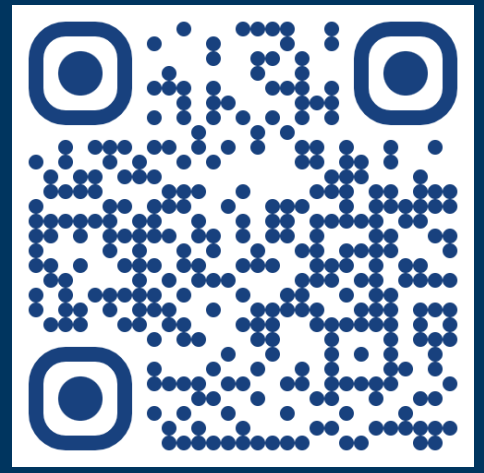
Conclusion

- BENNS's accuracy was good enough that we did not require the corrective step in any experiment.
- The hybrid approach enabled greater exploration of the search space without sacrificing speed (100 individuals in hybrid vs. 10 in online).
- The hybrid approach enables faster convergence across complicated problem scenarios.

Poster


University of Glasgow
BENNS: A SURROGATE FOR HYBRID ONLINE-OFFLINE EVOLUTION OF OPTIMAL SERVICE FUNCTION CHAIN EMBEDDING
Theviyanthan K.
hello@thivi.dev
School of Computing Science, University of Glasgow
Service Function Chaining (SFC)
Network Function Virtualisation (NFV)
Software Defined Networking (SDN)
Service Layer
SFC Embedding Challenges
Chain Composition
VNF Embedding
Link Embedding
Optimisation Goals
Maximise Acceptance Ratio
Minimise Traffic Latency
Genetic Algorithms (GAs)
Why GAs?
BENNS Surrogate Model
CPU Usage Predictors
Benchmarkers
Delay Benchmarker
Bandwidth Benchmarker
CPU Benchmarker
Approximator
Evaluation & Conclusion
Evaluation of Accuracy of BENNS
Evaluation of Hybrid Evolution
Conclusion

Questions



www.thivi.dev

Thank You

Appendix

Why Genetic Algorithms?

- It is a heuristic algorithm that can solve NP-hard problems.
- It can adapt to an uncertain/unknown environment.
- It is an underutilised algorithm in the SFC realm. Only 19/209 surveyed studies use GAs.