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GENETIC EVOLUTION OF SERVICE FUNCTION CHAIN EMBEDDING

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Service Function Chaining (SFC)

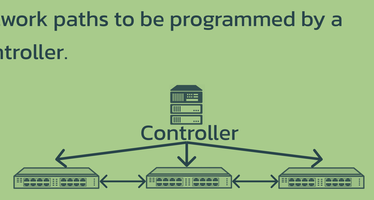
SFC combines NFV and SDN to create a service overlay over the physical network to make computer networks programmable. This takes us a step closer to autonomous networks.

Network Function Virtualisation (NFV)

NFV virtualises network functions such as a firewall and deploys them on servers.

Software Defined Networking (SDN)

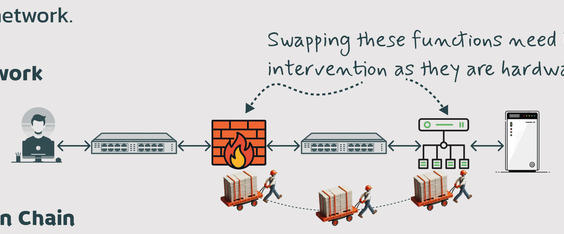
SDN separates the control plane of network switches from the data plane allowing network paths to be programmed by a controller.



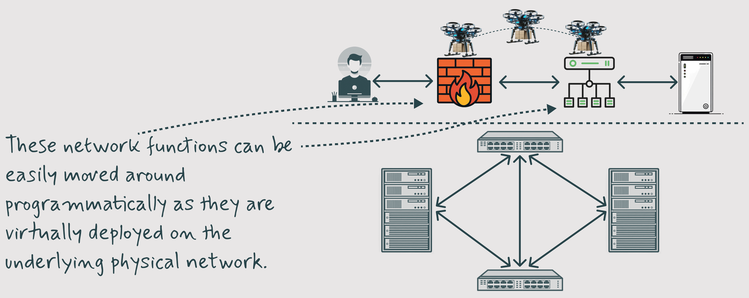
Service Layer

NFV is used to deploy Virtualised Network Functions (VNFs) and SDN is used to link them together on the physical network.

Traditional Network



Service Function Chain

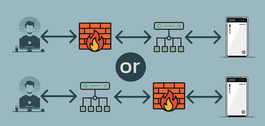


SFC Embedding Challenges

Embedding SFC on the physical network optimally is an NP-hard optimisation challenge. This optimal embedding problem is of three types. Studies show that an optimal solution solves all three types simultaneously.

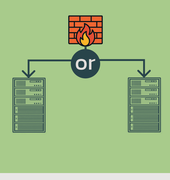
Chain Composition

How to optimally order the VNFs in an SFC?



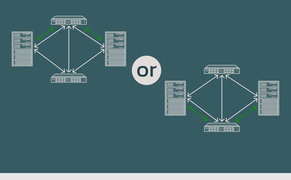
VNF Embedding

How to optimally deploy VNFs in servers?



Link Embedding

How to optimally route traffic between VNFs?



Optimisation Goals

Maximise Acceptance Ratio

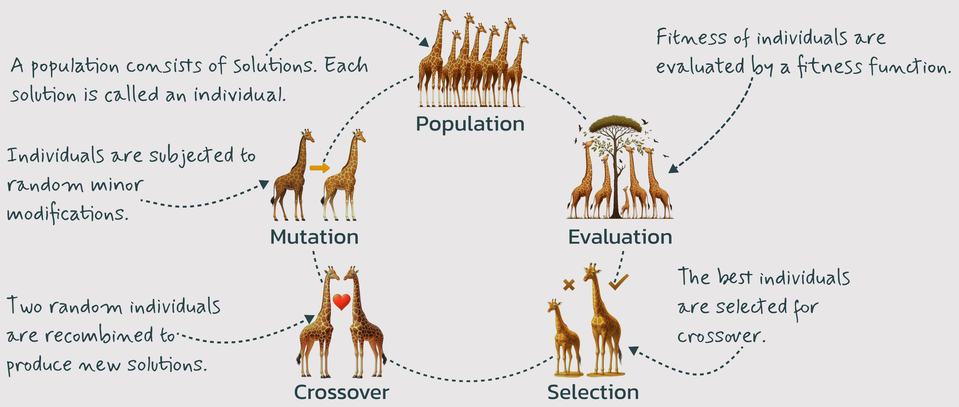
Acceptance Ratio is the number of SFCs that can be embedded over the number of requests received to embed SFCs.

Minimise Traffic Latency

Traffic latency is the roundtrip time traffic takes to traverse SFCs.

Genetic Algorithms (GAs)

GAs are metaheuristic algorithms that solve NP-hard optimisation problems. They apply the idea of evolution to solve optimisation problems by evolving solutions iteratively.



Why GAs?

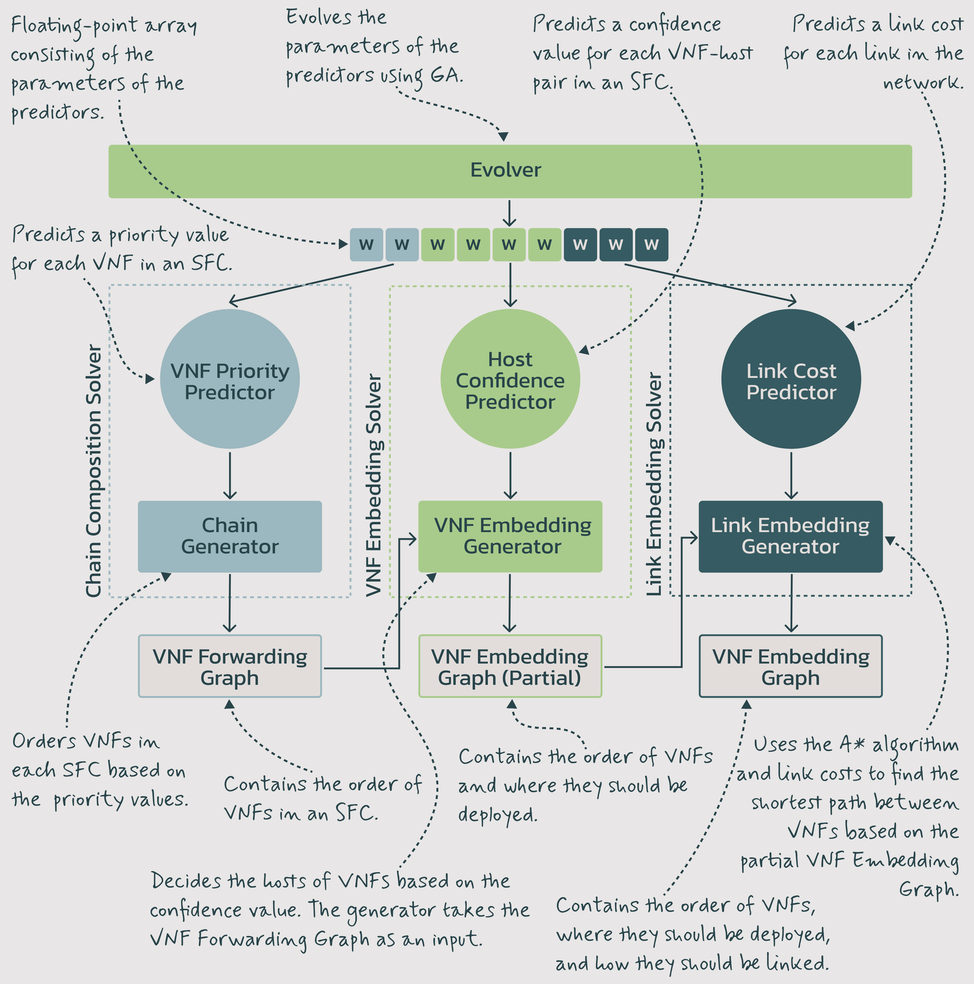
Only 12 of the 163 studies use GAs.	GAs adapt to dynamic network environment.	GAs don't need fitness function gradient.	GAs can search concurrently.

Genetic Evolution of SFC Embeddings

Two of the major challenges in using GAs are formulating a genetic encoding scheme to represent individuals and a function to evaluate the fitness of individuals.

Genetic Encoding

We can't use the usual encodings as we have to solve chain composition, VNF embedding and link embedding problems simultaneously. So, we evolve the parameters of three perceptrons (predictors) using a floating-point array as the encoding.

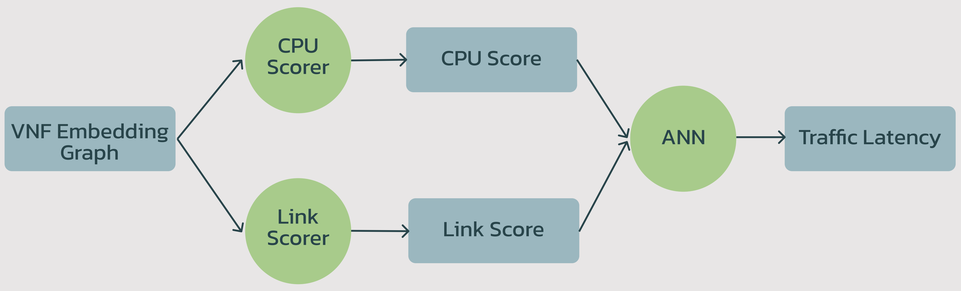


Fitness Evaluation

Modern networks are too complex to be simulated or numerically analysed. So, we use OpenRASE, an SFC emulator, to evaluate the traffic latency experimentally. This is called online experimentation. The acceptance ratio is calculated mathematically.

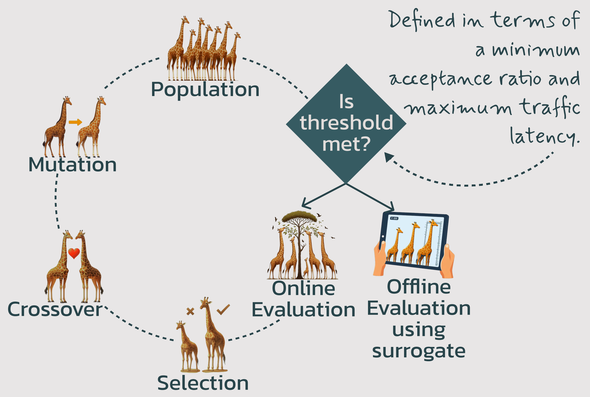
Surrogate

Evaluating using OpenRASE is time consuming. So, we developed a surrogate model to approximate the fitness of individuals. The surrogate is an Artificial Neural Network (ANN) that predicts the traffic latency for a given VNF Embedding Graph, which we encode to numerical values using CPU and link scorers that indicate resource utilisation.



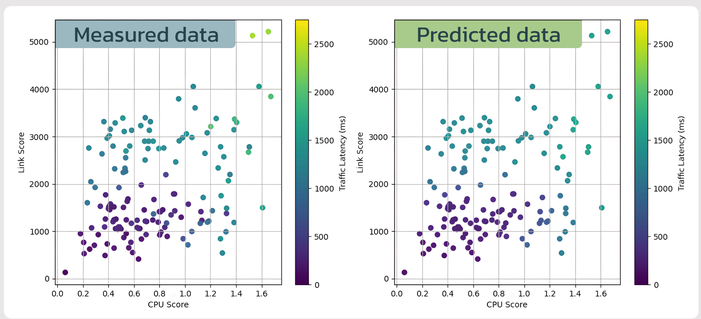
Hybrid Online-Offline Evolution

Evolving using the surrogate (offline) is fast but not accurate. Evolving using OpenRASE (online) is accurate but slow. So, we adopt a hybrid approach to get the best of both.



Conclusion

- The surrogate approximates fitness appreciably.
- Preliminary experiments show that hybrid evolution drastically reduces the time taken.
- Experiments to benchmark the performance against existing algorithms is in progress.



Scatter plots showing the measured traffic latency vs. the traffic latency predicted by the surrogate.