Applications of Machine Learning and Intelligent Algorithms for SDN and NFV

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Intelligent Networking
Next generation network challenges

• Convergence means the integration of these services over a common infrastructure and provision through a single point of attachment
  – Combining compute and connection resources for end-to-end services

• The customer expects:
  – Rapid delivery of new services
  – Greater bandwidth and scalability
  – Higher QoE and More sophisticated SLAs

• The provider needs to:
  – Drive up income from deployed resources
  – Find a way to deliver QoE and meet SLAs
  – Deploy agile management and controller platforms
  – Whilst reducing operational costs
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Solving current network problems

• Throwing resources at the problem?
  – A guaranteed fat pipe or over provisioning of compute resources is a good way to deliver quality

• But. Exceeding bandwidth and resource requirements will be expensive and impractical in the long-term
  – Inevitably, even in a lightly used network, some links reach critical utilisation
  – It can be hard to predict which links or compute resources will be affected in failure scenarios
  – New customers can cause unforeseen congestion points

• Better network planning and appropriate reoptimisation of services
  – Requires complex path computation capabilities
  – Model the entire network (multi-layer modelling)
  – Consider all current services and compute in parallel not sequentially
  – Respond to network events and deliver services in real-time
  – Requires online path computation capabilities
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Solving current network problems

• Support of complex transport services:
  – P2P and P2MP based service types
  – High levels of QoS demand multiple constraints
  – Minimal cost, minimal delay, high bandwidth
  – Constraints may be conflicting

• Multiple resources to support one service
  – Compute, storage, function and connectivity

• Resource continuity issues
  – Multi-layer networking
  – Non-Linear effects and Wavelength continuity

• Path diversity or congruence:
  – Mesh protection resource sharing
  – m:n protection

• Concurrent network-wide optimisation and frequent reoptimisation
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Network Operations

• Questions Operators asked themselves…
  – Where is my traffic flowing today?
  – Where do I place new resources, such as links, switches and functions?
  – What resource capacities do I require?
  – How do I design my network to minimise or negate the impact of resource failures?
  – What configuration metrics do I place on the network equipment that will influence traffic flows and quality of service?
  – Where is the most cost-effective place to add new resources to accommodate anticipated traffic growth?
  – What is the most effective mechanism for carrying new types of services?
  – Which protection mechanism is most effective for network topology and service types I currently have?
  – What if…?
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Existing computation techniques

• Single-service computations
  – CSPF is perfectly functional
    • Optimal paths for single LSPs with multiple constraints
  – Modified CSPF can compute multiple paths
    • Good for solving k-disjoint paths
  – Conventionally used to satisfy real-time requirements

• Linear programming can optimise a whole network
  – Can take long periods to develop
  – Not flexible to changing demands, new topologies, new constraints, or new service types

• But can it do it fast enough?
  – More constraints mean slower computation times
  – More paths mean more complex computation
  – Increasingly we see competing constraints
  – Larger networks are phenomenally complicated
**Intelligent Networking**  
**Comparing techniques**

- Conventional algorithms are deterministic  
  - Same solution every time  
  - Normally tuned to the specific technologies and services  
  - Not good at handling multiple service types  
  - Generally slow when handling large networks with many elements

- Non-heuristic processes assess a wider variety of data to derive solutions  
  - May produce a different, but correct solution each time  
  - Is able to handle a variety of topologies  
  - Would be capable of managing different service types
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What is Machine Learning?

• The complexity in traditional computer programming is in the code (programs that people write).

• In machine learning, learning algorithms are in principle simple and the complexity (structure) is in the data.
  – The way we automatically learn that structure is the heart of machine learning.

• A trained learning algorithm (e.g., neural network, boosting, decision tree, SVM, …) is highly flexible, capable of solving complex problems.
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When to use Machine Learning?

• When patterns exists in our data
  – Even if we don’t know what they are
    • Or perhaps especially when we don’t know what they are
    • Or if they are just noise

• We can not pin down the functional relationships mathematically
  – Else we would just code up the algorithm
  – Neural networks as function approximators
    • Need this for scale

• When we have lots of (unlabeled) data
  – Labeled training sets harder to come by
  – Data is of high-dimension
    • High dimension “features”
    • For example, sensor data
  – Want to “discover” lower-dimension representations
    • Dimension reduction
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Are we in the next Hype Cycle?

Wait..
Are we are here (again)?
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Next Steps for applying ML to Networking?

• Lots of open source ML frameworks, Cloud APIs, Examples, …
  – Google Tensorflow (tensorflow.org)
  – Facebook Torch (torch.ch)
  – Microsoft CNTK (github.com/Microsoft/CNTK)
  – Amazon MXNET (aws.amazon.com/mxnet)
  – Keras (keras.io/)
  – Theano (github.com/Theano)

• Lots of Network Data, but…
  – Standardized and labelled datasets are scarce
  – Most network data sources (e.g., NETFLOW) not designed for ML
  – Arbitrary data might be over-valued

• Skills gap persists, but… it still requires skill/experience to
  – Build DNN architectures/models
  – Finding ”good” settings for hyper-parameters
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Join IETF IDNet (Intelligence-Defined Network)

• The IDNet (Intelligence-Defined Network) is aiming to apply Machine Learning mechanisms network environment and react to dynamic situations.
  – https://www.ietf.org/mailman/listinfo/idnet

• Topics include, but not limited:
  – Better management & control of network technologies
  – Architecture or reference model for the Intelligence-Defined Network
  – Integrate IDN with various network infrastructure architectures and IETF standards
  – Data requirements for AI network controlling, including new measurement technologies
  – Network data selection, data structure & protocol for data transmission