



Part 3: Building an NDT for Next-Generation WLANs with Graph Neural Networks (GNNs)

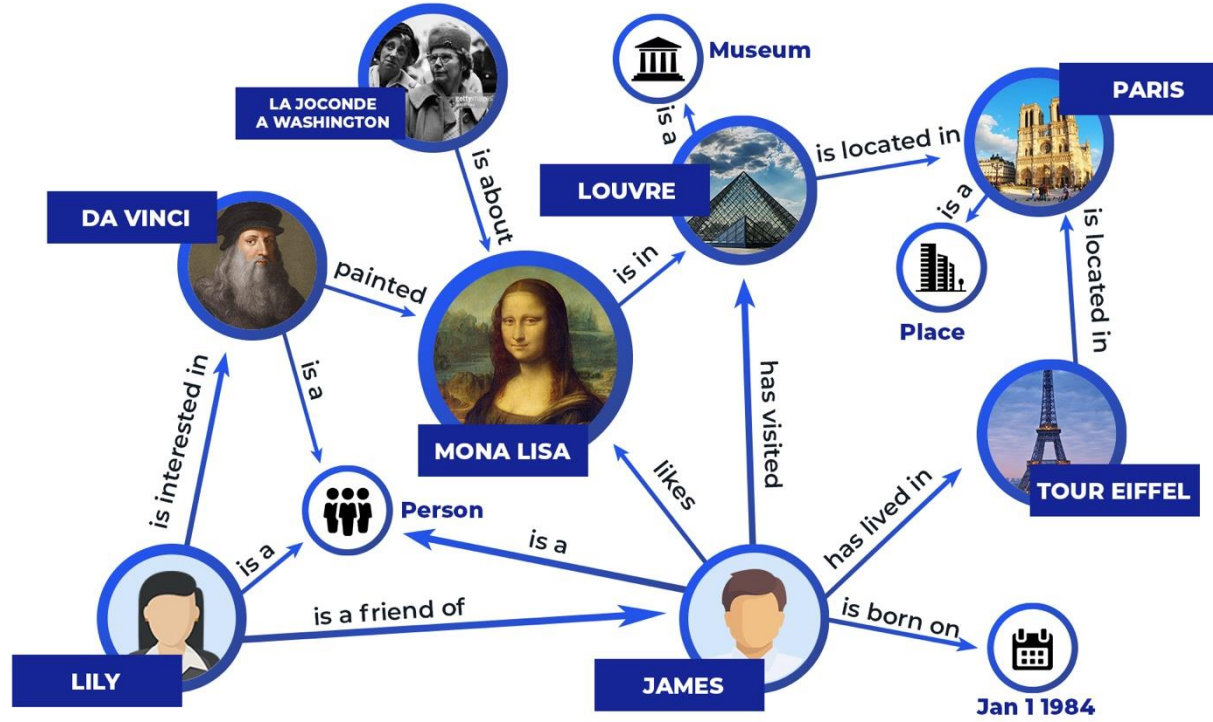
Miguel Camelo

Agenda

- Part 0 – Network Digital Twins – 6G-TWIN vision
 - Motivation
 - Technology enablers
 - Architectural concept
- Part I - Introduction to Wireless Networking Management
 - Background in Wi-Fi and its medium access mechanisms.
 - Background in Channel Bonding
 - Challenges in Channel Bonding
 - Necessity for digital twins
- Part II – Hands-on: Building an NDT for Next-Generation WLANs with traditional AI/ML/DL
 - Introduction to dataset
 - Introduction to AI/ML/DL techniques
 - Hands-on: Building an NDT with traditional AI/ML/DL
- **Part III – Hands-on: Building an NDT for Next-Generation WLANs using Graph Neural Networks**
 - Motivation for using Graph Neural Networks (GNNs) in topology-based problems
 - Introduction to GNNs
 - Hands-on: Building an NDT for Next-Generation WLANs using GNNs
- Part IV – What is next?

Why GNNs

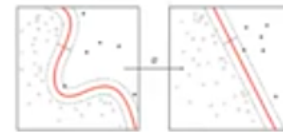
GNNs are good working with relational data



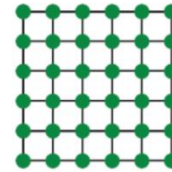
Source: <https://thetechbrook.com/inside-the-black-box-of-ai/>

Different Neural Networks

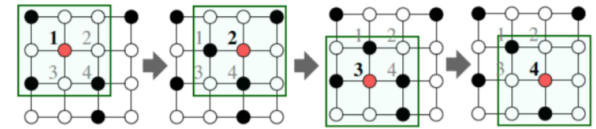
Type of NN	Information structure
Fully Connected	Arbitrary
Convolutional	Spatial
Recurrent	Sequential
Graph	Relational



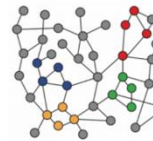
Generic classification,
non-linear regression



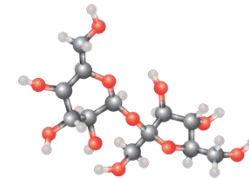
Images



Text



Networks



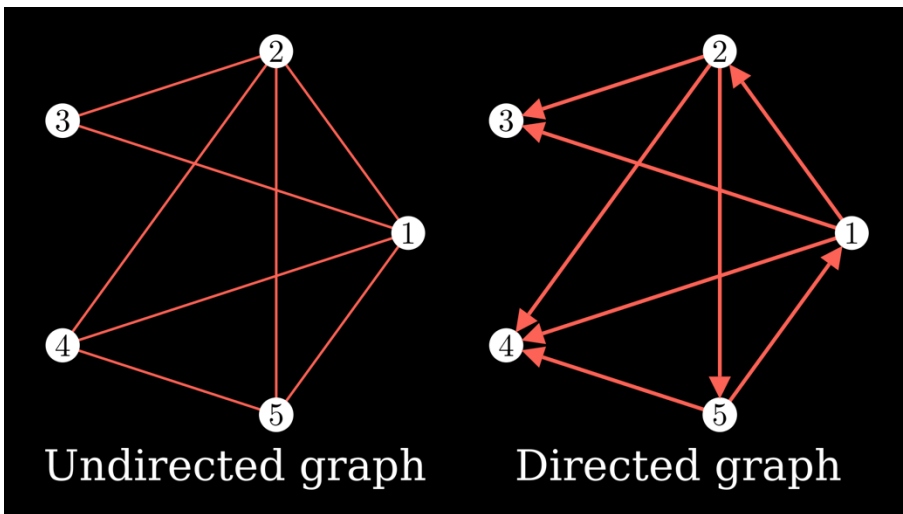
Molecules

Source: <https://neptune.ai/blog/graph-neural-network-and-some-of-gnn-applications>

Introduction to GNNs

What is a graph?

- A graph is 2-tuple $G=(V, E)$ where V are the nodes and E are the links.
- Each node has its own set of features.
- Optionally, each link has its own set of features

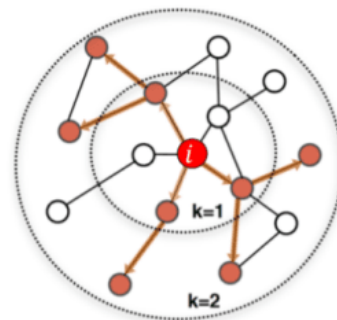


Source: <https://www.freecodecamp.org/news/graph-neural-networks-explained-with-examples/>

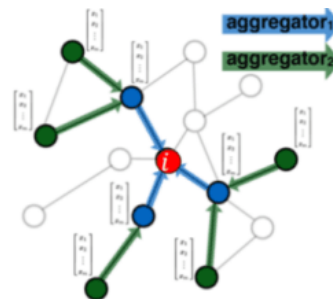
How GNNs work?

Aggregating information – Message passing

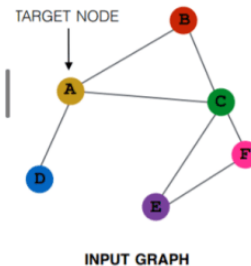
- Adjacency matrix: a mathematical way to express the graph.
- Exploit locality information.
- Order-invariant aggregators
 - Sum
 - Average
 - Maximum



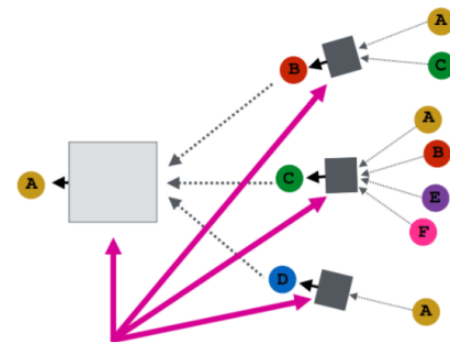
Determine node computation graph



Propagate and transform information



INPUT GRAPH

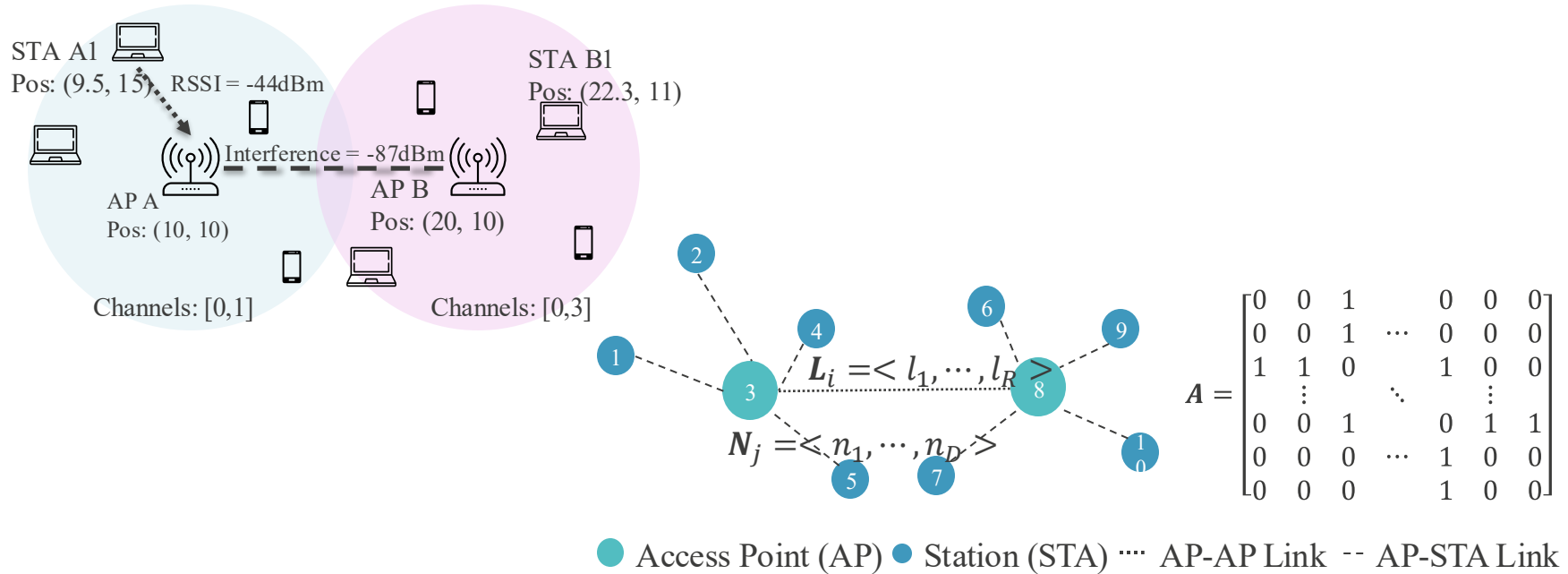


Neural networks

Source: <https://neptune.ai/blog/graph-neural-network-and-some-of-gnn-applications>

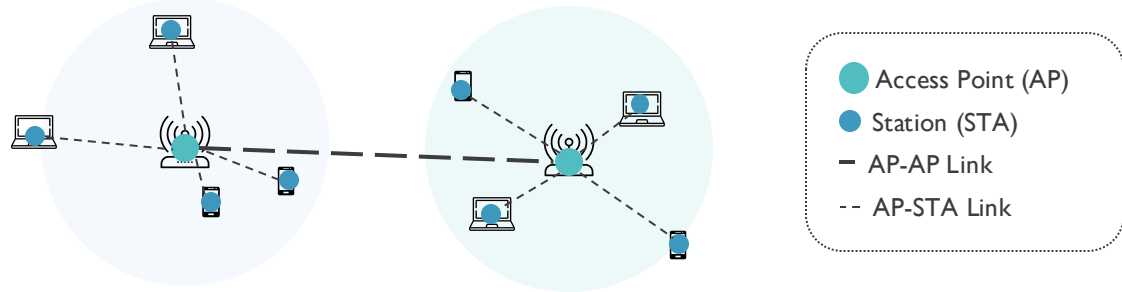
GNNs for solving topology-based problems

GNNs applied to WLANs



GNNs

Basic Model

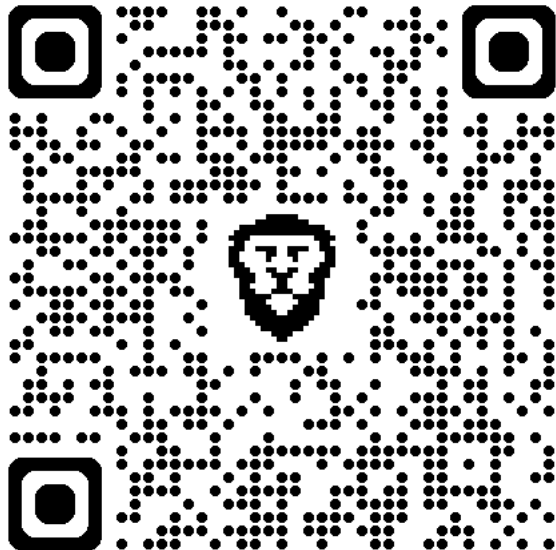


■ GNB³: Graph Neural Block

- Node attributes: node type, x-y coordinate, channel configuration
 - AP: mean airtime,
 - STA: SINR
- Edge attributes: edge type, distance
 - AP-AP: interference
 - AP-STA: RSSI
- Architecture
 - Node model
 - Edge model

Hands – On

Link



Notebook: Building an NDT for next-generation WLANs using GNNs

Google Colab

This tutorial can also run in Google Colab. There are two main notebooks, one for building the NDT - GNN and another to build the NDT - ML.

To access the notebook regarding the NDT - ML, please enter [here](#).

To access the notebook regarding the NDT - GNN, please enter [here](#).



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