AMLD EPFL

How Deep Learning is today used in production to help troubleshooting and improving the broadband services

10:00-10:25, January 28

NOKIA

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Talk/ Overview

For years, Nokia has positioned itself also as an AI company and is a key player of the 4th industrial revolution. Some of their latest in-house developments leverage deep learning to offer an accurate, proactive and network-wide solution to troubleshoot the internet access networks. Besides the value brought by the machine learning, a key aspect resides in the significant contributions of domain knowledge at each step of the design process. Through this talk, some of our best practices will be shared regarding the development of specific deep learning systems as well as some insights about the benefits of such systems to solve real-world broadband concerns. These developments have been awarded at the Nokia Bell Labs AI Conference.

Winner of the two last Global AI Conferences organized by Nokia Bell Labs, Distinguished Member of Technical Staff and main author of 30+ patents in the field of Broadband communication & AI, Nicolas Dupuis is a Tech. Lead for AI Innovation & Machine Learning developments within Nokia. His strong technical background and his long-term contact with the market led him to create pioneering product features globally deployed at major service providers.

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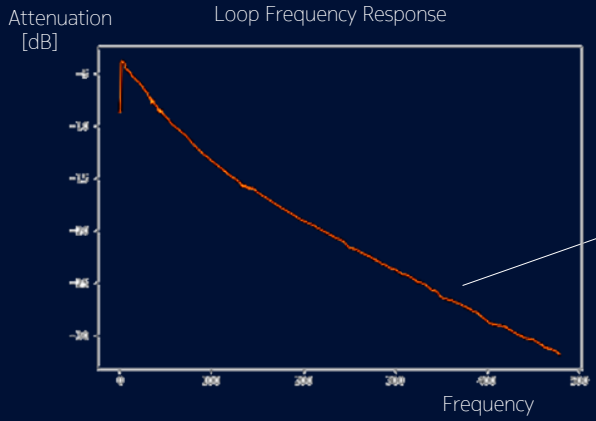
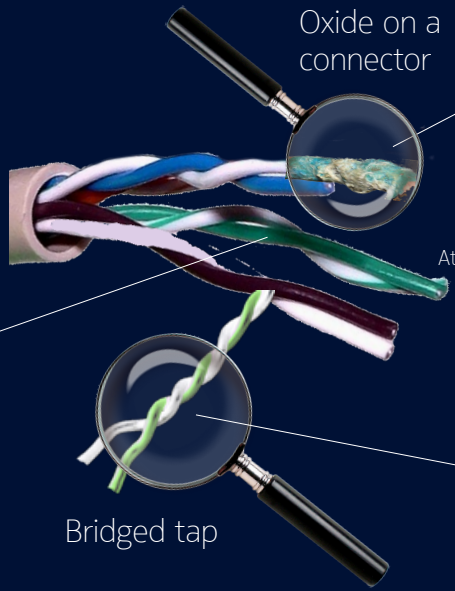
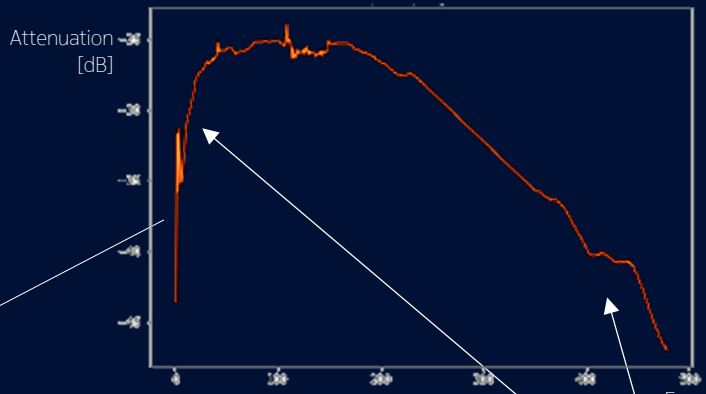
SIGNAL LOST

Diagnosis

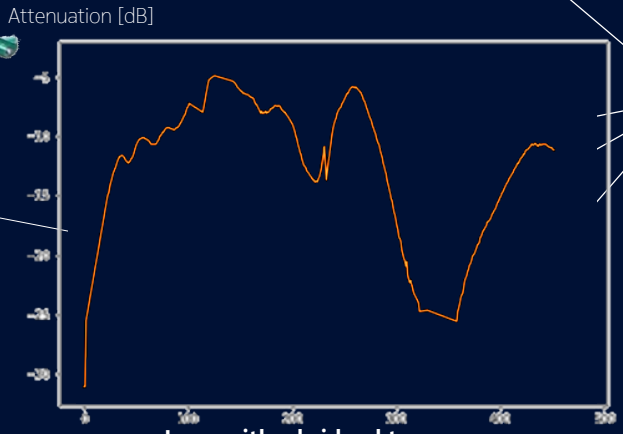


A healthy loop.





Loop with oxide on connector.



Loop with a bridged tap.

?

... and much more !

Broadband diagnosis with Deep Learning

Modem under pro-active supervision

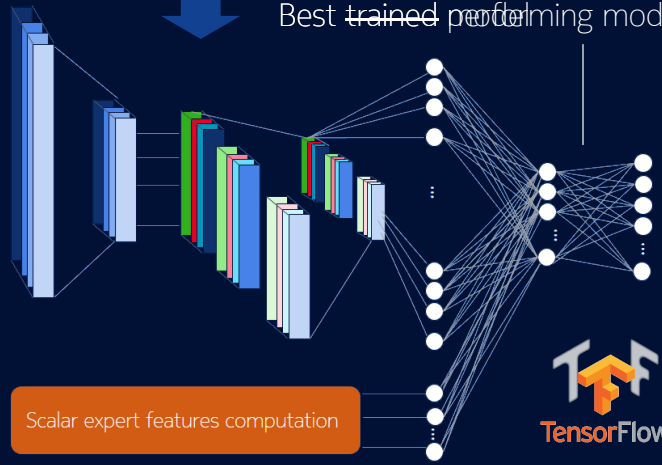
Domain expertise

Training set creation
Soft-labeling
Pre-processing
Scalar expert features

Data Science

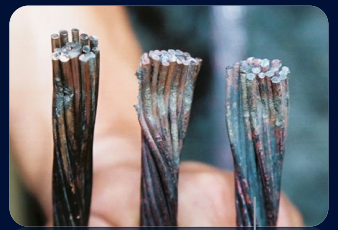
CNN design
Validation

Best ~~trained~~ performing model



Scalar expert features computation

TensorFlow



Identification of broadband connection impairments

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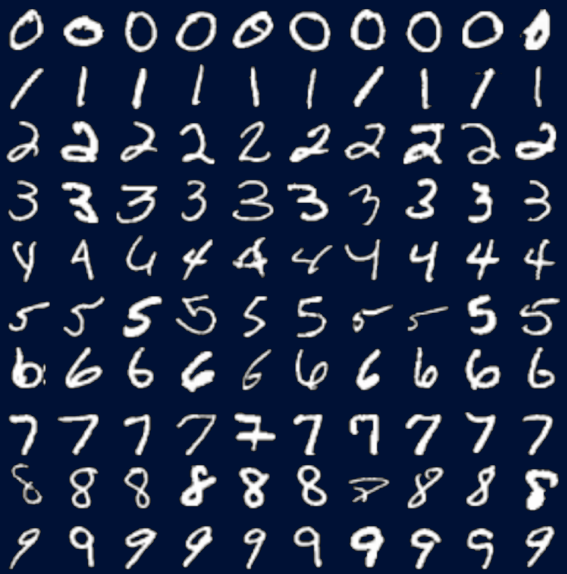
Broadband diagnosis with Deep Learning

Soft-labeling



MNIST handwritten digits

- « Experts » (e.g. humans, authors) labelled formally each digit.
- No ambiguity is assumed during the training set creation (hard-labelling).

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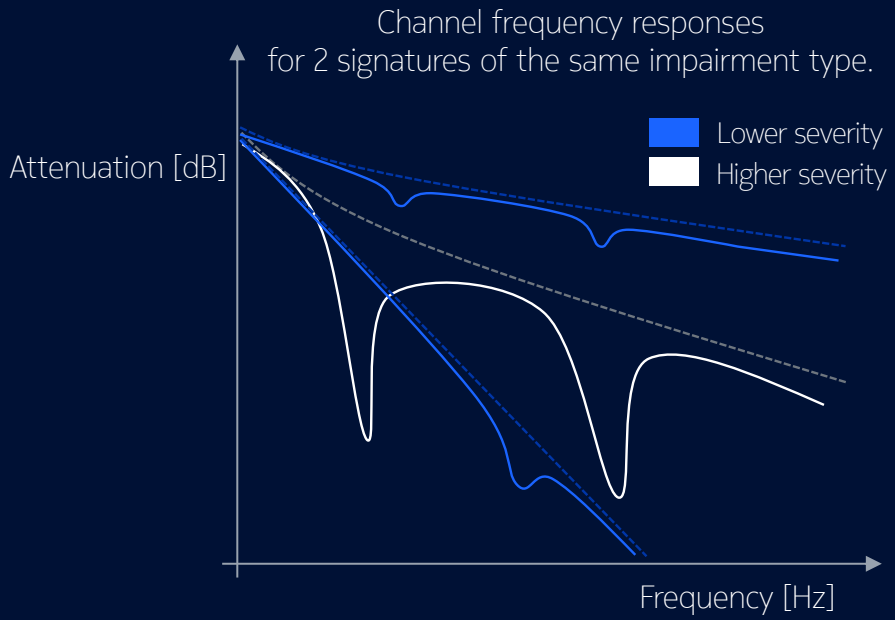
Soft-target labeling



- In problem detection, there is the notion of « severity ».
- This means within the same class of problem, the returned confidence needs also to reflect such severity.
- Solution is to make use of soft-labelling.
- Domain knowledge is required to assist deriving such soft-labels.

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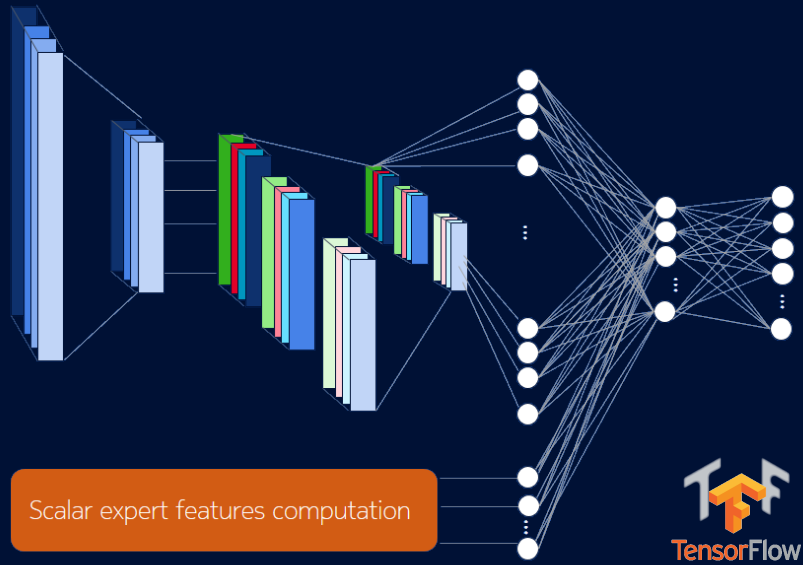
Expert scalar features addition



- Having the « optimal trained model » would require to build the « optimal training set ».
- Building a large, various and unbiased training set is hard (see next section).
- The convolutional layers might get therefore biased, leading to extra sensitivity.
- Adding empirical quantities to the fully-connected layer have helped in gaining in robustness (conservative approach).

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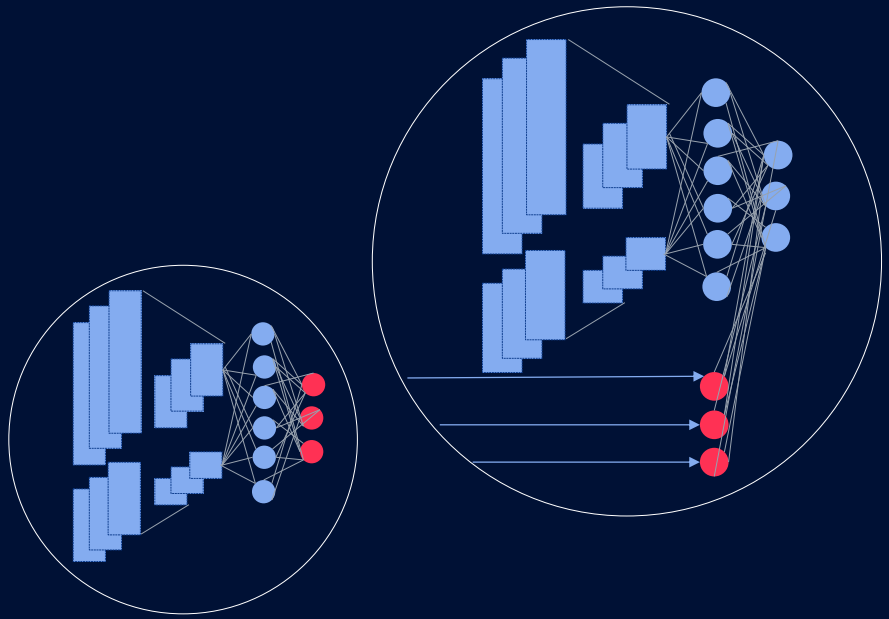
Training set

- The training set is the key !
- You are in the Professor role. You need to select the right maters/books/topics and to balance them properly.
- Building a large, various and unbiased training set is hard, but necessary.
- Machine Learning is not Data Science, be imaginative to build your « training library ».
- Multi-labelling opens the door to interconnection of Deep Learning models.

Broadband diagnosis with Deep Learning

Deep Learning pipeline



- Still in the Professor role, some intermediate maters can help/are necessary for learning more complex ones.
- It may be challenging to train larger deep learning networks, without guarantees on the learned aspects.
- From a domain perspective, some intermediate quantifities may be relevant to be learnt.
- In order to benefit from this knowledge and to force to focus on the right aspects, intermediate trained models might be relevant to be trained.
- Their outputs are used as inputs for other DL models, hence moving from DL models to DL pipelines.

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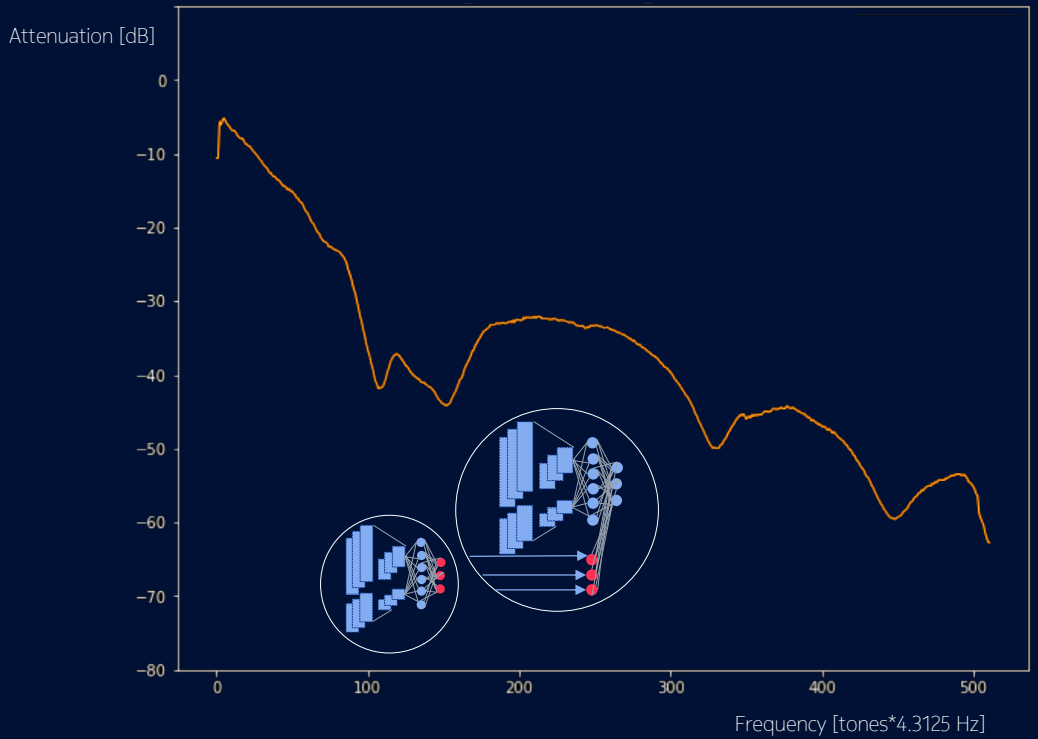

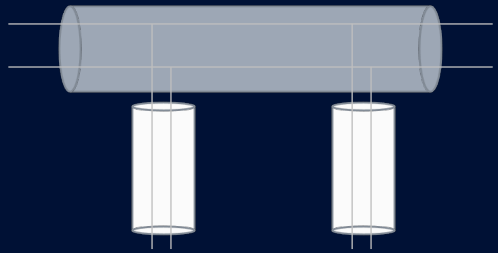

- 2 bridged taps ✓

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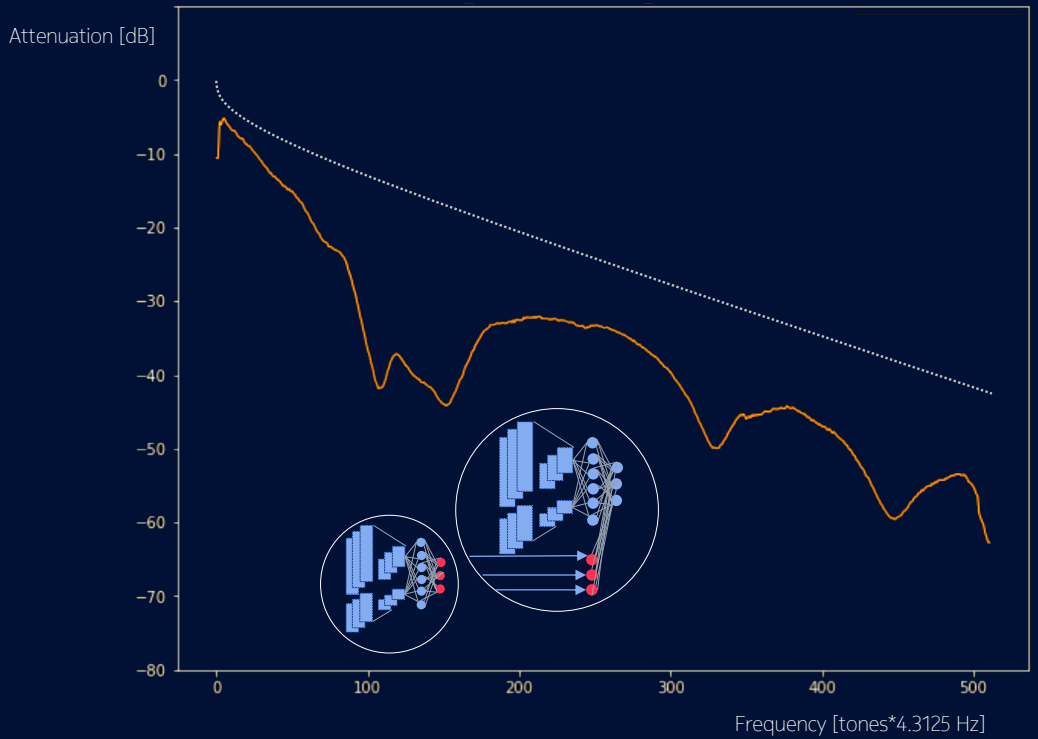

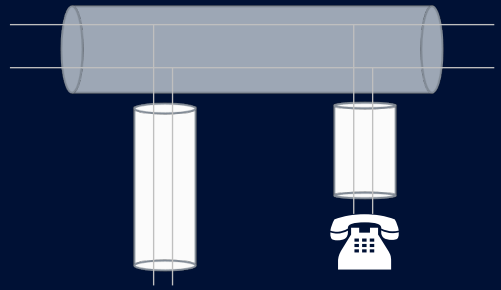

- 2 bridged taps ✓
  - A long: 13.97 [m] (reality: 13.91 [m]) ✓
  - A short: 7.43 [m] (reality: 7.62 [m]), terminated by a phone. ✓
- Speed impact: 62 [Mbps] ✓

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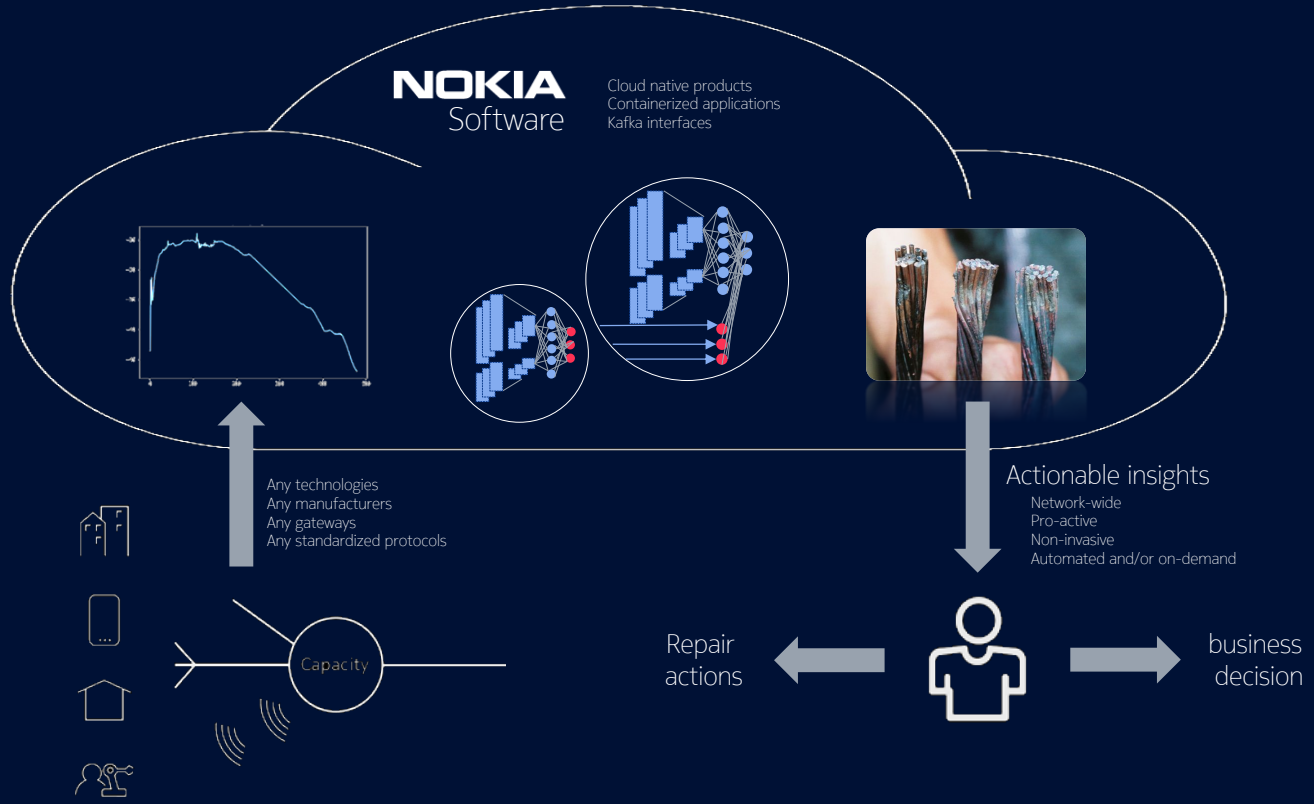
Solution



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Broadband diagnosis with Deep Learning

	Empirical algorithms	Machine Learning	Deep Learning	Deep Learning + domain knowledge
Top accuracy	<50%*	>85%	>95%	>95%
Capabilities	★	★★	★★★	★★★★
Field performances	★	★★	★★	★★★★

Quality of insights much valuable for the business.

* Narrower coverage.

Broadband diagnosis with Deep Learning

From the field…

- Most of the wiring issues detected and recognized*.
- 95% of correct/helpul diagnosis reported by field technicians*.
- Very low false positive rate*
  (good lines are accurately qualified as such).
- Severity/Impact accurate and helpful*.

* These metrics have been obtained out-of a formal validation campaign, with systematic feedbacks from field technicians, that has been conducted over a long term period with a major European service provider.

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Broadband diagnosis with Deep Learning

Benefits

- Time-to-resolution shortered, both on directly & indirectly related issues*.
- Overall efficiency in troubleshooting process improved*.
- AI highly adopted by telco staff, helping them in their daily job* !

"Nokia's AI driven access analytics solution has given us the ability to proactively address issues, reducing customer calls by solving multiple issues in a single intervention and creating overall efficiencies in our troubleshooting process."

- Patrick Rausch, Senior Project Manager, POST Luxembourg
* More information on this case study

AI for Broadband Troubleshooting

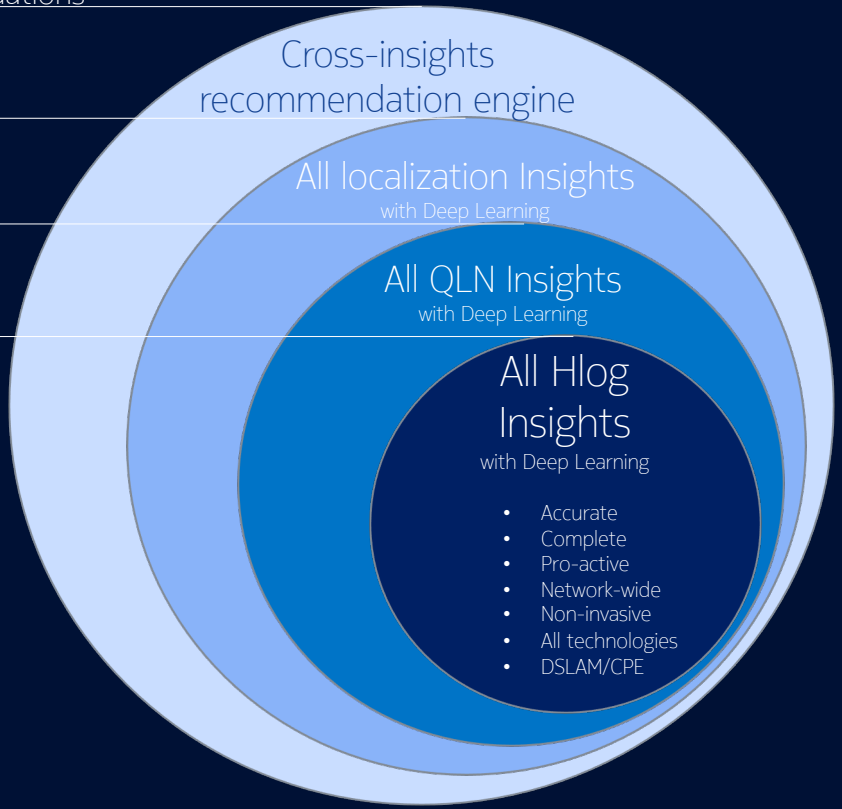
Network-wide proactive actionable recommendations

Complete loop diagnosis & fault localization

Complete loop diagnosis

Quantification of PHY (Channel+Noise) contribution on service impact.

Copper (channel) fault diagnosis



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Broadband diagnosis with Deep Learning

DevOps

- Pipeline design
- Pre-/Post-processing
- Specific genetical search for parameter tuning
- Robust early-stopping
- Production-level code

- CNN model
- Expert scalar features computation
- Specific « callbacks » (e.g. robust ES).
- Trained model/session storage
- TFrecords

- Larger data sets manipulation/preparation
- Distributed genetical hyper-parameter tuning
- Distributed execution
- Training over >20M samples
- Training over >30 generations