



Radio Link Failure Prediction

AI for Good – Machine Learning in 5G Challenge

Evren Tuna – 5G R&D Expert

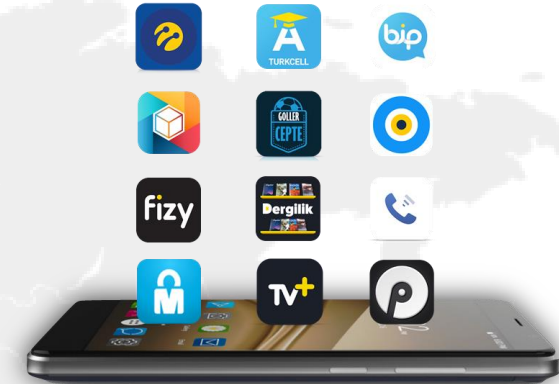
14.06.2021



Turkcell Group Snapshot



Network Operator



Experience Provider

- **THE DIGITAL OPERATOR**
- **~50 MILLION TURKCELL GROUP SUBSCRIBERS in 5 COUNTRIES**
- **~180 MILLION DIGITAL SERVICES DOWNLOADS GLOBALLY**
- **~86 MILLION DIGITAL SUBSCRIBERS GLOBALLY**
- **LISTED ON NYSE & BORSA ISTANBUL WITH A \$5 BILLION MARKET CAP**

R&D Activities



R&D Focus Areas

AI/ML for Telco (SON, Automation)
Cellular V2X Communications
Network Slicing
Edge Computing
RAN
Drone Communications
Industry 4.0 / IoT / Robotics
Non-Terrestrial Network
Open Networks



R&D Projects

15 R&D Projects

H2020, TÜBİTAK, CELTIC+
funded

Affiliations-Standards



ITU-T Study Group 13:
Focus Group on Autonomous Networks
Technologies for Network 2030 (FG NET-
2030)



Turkcell is a member of 5G PPP since 2017



Following the activities of RAN 2, which
specifies the radio interface architecture and
protocols for UTRA and beyond
Turkcell is a member of ETSI/3GPP since 2018



*Turkcell joined TELECOM INFRA PROJECT (TIP)
in 2017*



Member of the Board of Directors
Represented by the CEO of Turkcell



A collaborating-innovator of ONF
Working on R-, E- and M-CORD platforms
Turkcell is a member of ONF since 2018

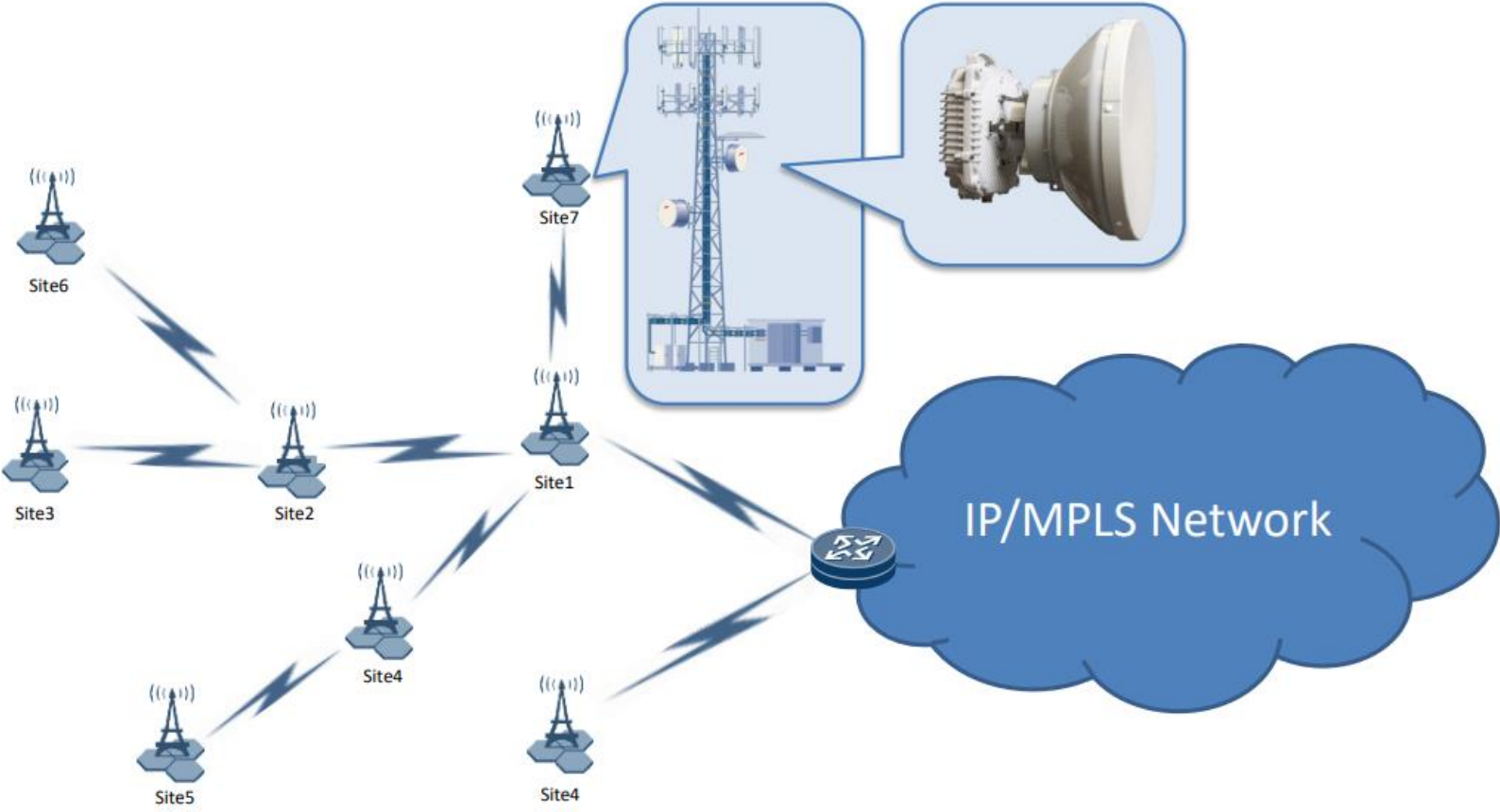


Trial and Test Initiative (TTI) Precommercial
Network Trials Co-lead Operator for 5G
Turkcell is a member of NGMN since 2013



The Challenge

Background



- Rain, snow, wind, fog, and other weather-related phenomena affects the performance of radio links

Related Works

- Y. S. Meng, Y. H. Lee and B. C. Ng, "The Effects of Tropical Weather on Radio-Wave Propagation Over Foliage Channel," in IEEE Transactions on Vehicular Technology, vol. 58, no. 8, pp. 4023-4030, Oct. 2009, doi: 10.1109/TVT.2009.2021480.



Fig. 1. Plantation under measurement.

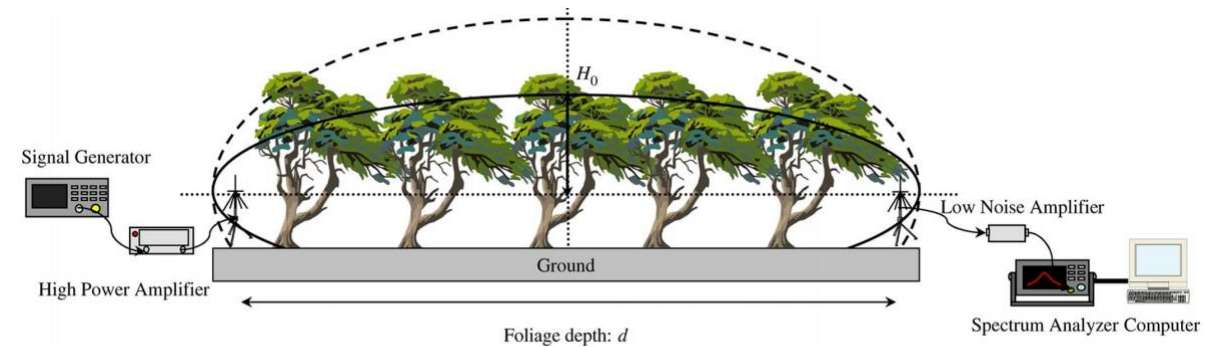


Fig. 2. Schematic diagram of the measurement setup and generic views of the first Fresnel zones (240 MHz -----; 700 MHz -----).

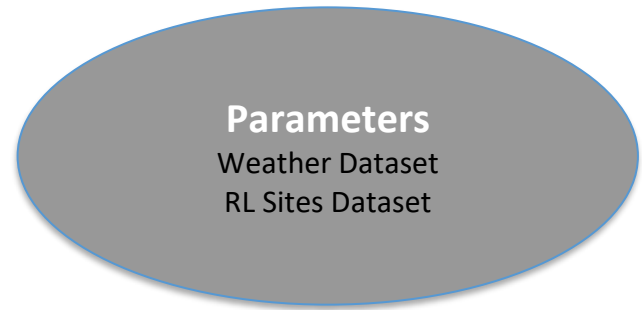
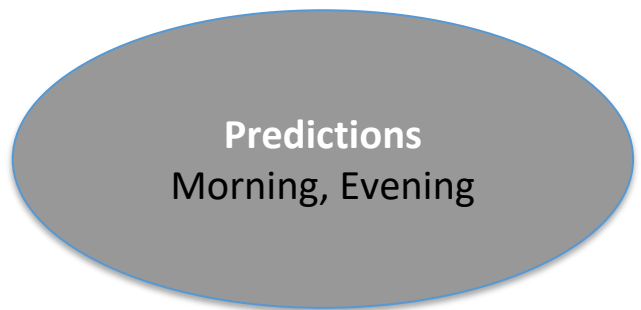
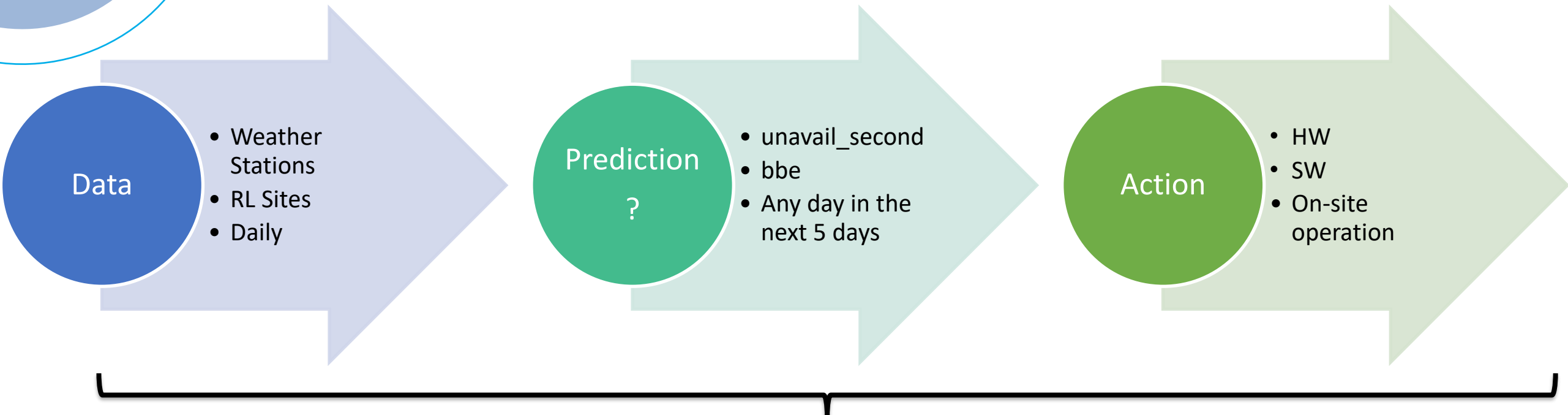


Related Works

- T. Tamir, "On radio-wave propagation in forest environments," in *IEEE Transactions on Antennas and Propagation*, vol. 15, no. 6, pp. 806-817, November 1967, doi: [10.1109/TAP.1967.1139054](https://doi.org/10.1109/TAP.1967.1139054).
- M. Meeks, "VHF propagation over hilly, forested terrain," in *IEEE Transactions on Antennas and Propagation*, vol. 31, no. 3, pp. 483-489, May 1983, doi: [10.1109/TAP.1983.1143066](https://doi.org/10.1109/TAP.1983.1143066).
- R. K. Tewari, S. Swarup and M. N. Roy, "Radio wave propagation through rain forests of India," in *IEEE Transactions on Antennas and Propagation*, vol. 38, no. 4, pp. 433-449, April 1990, doi: [10.1109/8.52261](https://doi.org/10.1109/8.52261).
- J. Pudashine et al., "Probabilistic Attenuation Nowcasting for the 5G Telecommunication Networks," in *IEEE Antennas and Wireless Propagation Letters*, vol. 20, no. 6, pp. 973-977, June 2021, doi: [10.1109/LAWP.2021.3068393](https://doi.org/10.1109/LAWP.2021.3068393).
- Jacek Rak, Rita Girão-Silva, Teresa Gomes, Georgios Ellinas, Burak Kantarci, Massimo Tornatore, "Disaster resilience of optical networks: State of the art challenges and opportunities", *Optical Switching and Networking*, vol. 42, pp. 100619, 2021.



Problem





Dataset

- **Training data includes pre-processed and anonymised RL KPIs from our networks and time-aligned weather data.**
- **RL data**
 - **KPI data includes date/time, frequency band, link length, error and failure statistics, availability ratio, stability score, capacity, modulation (128QAM, 256QAM, 512QAM, ...)**
- **Weather data**
 - **Forecast data includes status, temperatures, humidity, wind speed and direction for the following 5 days (Recorded twice a day)**
 - **Measurement data includes temperatures, humidity, wind speed and direction, precipitation and overcast (Recorded hourly)**
- **Distances**
 - **A matrix that gives distance for weather stations and RL sites**

Dataset

rl-kpis

type	RL equipment vendor
datetime	Date and timestamp
end-point	link end-point (NEAR/FAR)
mlid	Mini link ID
mw_connection_no	Unique internal connection ID
site_no	Site no
site_id	Site ID
polarization	RL antenna polarization (Vertical/Horizontal)
card_type	RL modem card type
adaptive_modulation	Whether adaptive modulation is available
freq_band	Frequency band
link_length	Distance between two sites (LOS)
severaly_error_second	Count of 1 sec periods with error that covers $\geq 30\%$ of the frame
error_second	Count of 1 sec periods with error
unavail_second	RL unavailable operation duration in seconds
avail_time	RL active time in seconds
bbe	Indicator of performance degradation. Background bit error count.
rxlevmax	RL received power level
scalibility_score	enabled
capacity	RL capacity
modulation	Modulation deployed

rl-sites

site_no	Site no
site_id	Site ID
clutter_class	E.g. average-dense-urban, open in urban, sparse tree, etc.

met-stations

station-no	Weather station no
clutter_class	E.g. average-dense-urban, open in urban, sparse tree, etc.

distances

RL_xyz	Radio link site
WS_123	Weather station no



Submissions

- **Predictions for RLF for the test data set (in CSV format)**
- **Trained ML model**
- **Design documentation and documented code**
- **Presentation on the approach, solution and results**



Evaluation Criteria

- **Participants must use the provided data set to train a machine learning algorithm**
- **The output of the ML algorithm should be able to predict the performance obtained in a new network deployment**
- **The choice of the ML approach is decided by each participant**
- **A test data set will be provided to evaluate the performance of the proposed algorithms**
- **The evaluation of the proposed algorithms will be based on the average squared-root error obtained along with all the predictions compared to the actual result in each type of deployment**
- **The winners will be given prizes (and may be invited to publish the results in an academic publication or present in a conference, etc)**

Turkcell Challenge Team



İlker Bilge

ilker.bilge@turkcell.com.tr



İ. Hakkı Özçelik

ismail.ozcelik@turkcell.com.tr



Semih Aktaş

semih.aktas@turkcell.com.tr



Evren Tuna

evren.tuna@turkcell.com.tr





Thank you!