Power Consumption Prediction for Virtualized Base Stations Using Transfer Learning

Overall Goal

The overall goal of this project is to study the machine learning methods for predicting power consumption in virtualised radio access networks. The project mainly focuses on using transfer learning techniques to improve the prediction accuracy in target scenarios with limited data. Experimental uplink power datasets (UL power datasets) are used to test and validate the proposed approaches.

Background

The increasing use of virtualization in mobile network systems, such as virtualized base stations (vBS), provides high flexibility and cost efficiency for modern wireless networks. Accurately modeling and predicting the power consumption of virtualized base stations is difficult. This is because wireless parameters, such as modulation, coding, airtime, and transmission power, interact with computing resources in a complex way. Traditional analytical models usually have limited generalization ability across different system settings.

Recent studies show that machine learning methods can effectively predict power consumption using system-level parameters. In real systems, building these models usually needs a large amount of experimental data. Collecting enough data for each new platform or system setting is time-consuming and expensive. This limits the practical use of methods that depend only on data.

The objective of this project is to study transfer learning methods for power consumption prediction in virtualized base station environments. This work is based on publicly available experimental datasets, an uplink (UL) power dataset. It studies whether knowledge learned from one dataset can be reused in a related dataset. The aim is to improve prediction accuracy when only a small amount of target data is available.

Objectives

- To study existing research on power consumption modeling and prediction for virtualized base stations and related wireless systems.
- To analyse the new publicly available uplink power consumption datasets for virtualised base stations.
- To compare different experimental datasets, identifying common input features and prediction targets which are suitable for transfer learning.
- To develop a baseline machine learning model for power consumption prediction using a single dataset.

- To apply transfer learning techniques between related UL power datasets and original processing dataset to test their effectiveness.
- To compare transfer learning models performance against baseline models using appropriate error metrics such as mean absolute error (MAE) and mean squared error (MSE) and to analyse the effectiveness of transfer learning.

Plan Of Work

The work is structured into several stages, and each stage is associated with a clear milestone.

Stage 1: Dataset Identification, Comparison, and Problem Definition
This stage focuses on finding suitable datasets. First, review the relevant literature on power consumption modelling in virtualized O-RAN and vBS systems to understand existing approaches and commonly used system parameters. Then, publicly available experimental datasets will be identified and compared based on their features, measurement set-ups, and data properties. Special attention will be given to assessing whether the datasets are collected independently and whether they are suitable for transfer learning.
Milestone: *Two suitable and independent datasets identified and the research problem finalised.*

Stage 2: Dataset Preprocessing and Exploratory Analysis
In this stage, the selected datasets will be prepared for modelling. This includes data cleaning, handling missing values, and normalizing features. Simple data analysis will be used to understand the data distribution and compare the similarities and differences between datasets. Common features will be matched for transfer learning, and any unavoidable differences will be recorded and analysed.
Milestone: *Cleaned datasets and completed exploratory data analysis.*

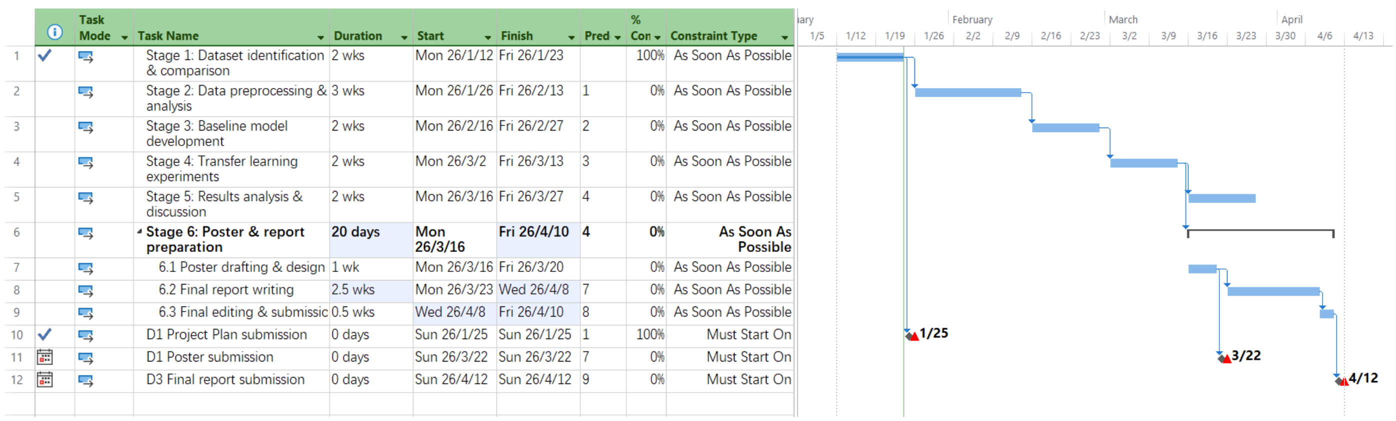
Stage 3: Baseline Model Development
This stage aims to establish baseline models for power consumption prediction. Machine learning models will be trained separately on each dataset, without using a transfer learning model. Model performance will be tested using suitable error metrics to measure prediction accuracy. These results will be used as a reference for assessing the benefits of transfer learning later.
Milestone: *Baseline models trained and evaluated.*

Stage 4: Transfer Learning Implementation
During this stage, transfer learning methods will be used to improve prediction performance when target data is limited. Models trained on the source dataset will be adapted to the target dataset using approaches such as fine-tuning or feature-based transfer. Experiments will be carried out with small amounts of target data. The results will be compared with baseline models to evaluate the benefit of transfer learning.
Milestone: *Transfer learning models completed and validated.*

Stage 5: Results Analysis and Discussion
This stage focuses on analysing and explaining the experimental results. The performance of baseline and transfer learning models will be compared in detail. The impact of dataset differences on model generalization will be discussed. The Key results will be summarized and related to the original research questions.
Milestone: *Final experimental results analysed and discussed.*

Stage 6: Poster and Final Report Preparation
In the final stage, all project results will be organized into the required deliverables. A project poster will be prepared and submitted by 22.03.26. At the same time, the final project report will be written, revised, and formatted for submission by 12.04.26.
Milestone: *Poster and final report successfully submitted.*

Gantt Chart:



	Task Mode	Task Name	Duration	Start	Finish	Pred	% Com	Constraint Type
1		Stage 1: Dataset identification & comparison	2 wks	Mon 26/1/12	Fri 26/1/23		100%	As Soon As Possible
2		Stage 2: Data preprocessing & analysis	3 wks	Mon 26/1/26	Fri 26/2/13	1	0%	As Soon As Possible
3		Stage 3: Baseline model development	2 wks	Mon 26/2/16	Fri 26/2/27	2	0%	As Soon As Possible
4		Stage 4: Transfer learning experiments	2 wks	Mon 26/3/2	Fri 26/3/13	3	0%	As Soon As Possible
5		Stage 5: Results analysis & discussion	2 wks	Mon 26/3/16	Fri 26/3/27	4	0%	As Soon As Possible
6		**Stage 6: Poster & report preparation**	**20 days**	**Mon 26/3/16**	**Fri 26/4/10**	**4**	**0%**	**As Soon As Possible**
7		6.1 Poster drafting & design	1 wk	Mon 26/3/16	Fri 26/3/20		0%	As Soon As Possible
8		6.2 Final report writing	2.5 wks	Mon 26/3/23	Wed 26/4/8	7	0%	As Soon As Possible
9		6.3 Final editing & submissic	0.5 wks	Wed 26/4/8	Fri 26/4/10	8	0%	As Soon As Possible
10		D1 Project Plan submission	0 days	Sun 26/1/25	Sun 26/1/25	1	100%	Must Start On
11		D1 Poster submission	0 days	Sun 26/3/22	Sun 26/3/22	7	0%	Must Start On
12		D3 Final report submission	0 days	Sun 26/4/12	Sun 26/4/12	9	0%	Must Start On

Risk Analysis:

Risk	Likelihood	Impact	Mitigation
Dataset incompatibility	Low-Medium	High	Early feature alignment
Limited target data	Medium	Medium	Use baseline models and restrict model complexity to avoid overfitting
No TL performance gain	Low–Medium	Medium	Clear result analysis (include negative findings)
Poster time pressure	Medium	High	Early drafting
Report deadline risk	Low–Medium	High	Early writing