# LTE

Mobile communications is on to its fourth generation of network infrastructure with LTE (Long Term Evolution) (4G). This network infrastructure is an improvement upon Universal Mobile Telecommunications System (UMTS), which is a third generation network (3G). LTE has downlink (DL) speeds of up to 300 Mbit/s and uplink (UL) speeds of 75 Mbit/s. This development was driven by the users want of faster download speeds for mobile services such as Video Streaming.

Specs and such

Maybe talk about IP based core network

# Handover Procedure

## Parameters

|  |  |
| --- | --- |
| Parameter | Value (dB) |
| hys | 0.0 |
| 0.5 |
| 1.0 |
| 1.5 |
| 2.0 |
| 2.5 |
| 3.0 |
| 3.5 |
| 4.0 |
| 4.5 |
| 5.0 |
| 5.5 |
| 6.0 |
| 6.5 |
| 7.0 |
| 7.5 |
| 8.0 |
| 8.5 |
| 9.0 |
| 9.5 |
| 10.0 |

|  |  |
| --- | --- |
| Parameter | Value (s) |
| TTT | 0.0 |
| 0.04 |
| 0.064 |
| 0.08 |
| 0.1 |
| 0.128 |
| 0.16 |
| 0.256 |
| 0.32 |
| 0.48 |
| 0.512 |
| 0.64 |
| 1.024 |
| 1.280 |
| 2.56 |
| 5.12 |

## Triggers

There are eight different triggers for sending a measurement report

|  |  |
| --- | --- |
| Event Type | Trigger Criteria |
| A1 | Serving becomes better than a threshold. |
| A2 | Serving becomes worse than a threshold. |
| A3 | Neighbour becomes offset better than PCell. |
| A4 | Neighbour becomes better than threshold. |
| A5 | PCell becomes worse than threshold1 and neighbour becomes better than threshold2. |
| A6 | Neighbour becomes offset better than SCell. |
| B1 | Inter RAT neighbour becomes better than threshold. |
| B2 | PCell becomes worse than threshold1 and inter RAT neighbour becomes better than threshold2. |

# Machine learning

Machine learning is a form of artificial intelligence (AI) that involves designing and studying systems and algorithms with the ability to learn from data. This field of AI has many applications within research (such as system optimisation), products (such as image recognition) and advertising (such as adverts that use a users browsing history). There are many different paradigms that machine learning algorithms use. Algorithms can use training sets to train an algorithm to give appropriate outputs; other algorithms look for patterns in data; while others use the notion of rewards to find out if an action could be considered correct or not. Three of the most popular types of machine learning algorithms are:

Supervised learning is where an algorithm is trained using a training set of data. This set of data includes inputs and the known outputs for those inputs. The training set is used to fine-tune the parameters in the algorithm. The purpose of this kind of algorithm is to learn a general mapping between inputs and outputs so that the algorithm can give an accurate output for an unknown input. This type of algorithm is generally used in classifier systems.

Unsupervised learning algorithms only know about the inputs they are given. The goal of such an algorithm is to try and find patterns or structure within the input data. Such algorithm would be given inputs and any patterns that are contained would become more and more common the more inputs the algorithm is given.

Reinforcement learning uses an intelligent agent to perform actions within an environment. Any such action will yield a reward to the agent and the agent’s goal is to learn about how the environment reacts to any given action. The agent then uses this knowledge to try and maximise its reward gains.

# Reinforcement Learning

In reinforcement learning an intelligent agent is learning what action to do at any given time to maximise the notion of a reward. In the beginning the agent has no knowledge of what action it should take from any state within the learning environment. It must instead learn through trail and error, exploring all possible actions and finding the ones that perform the best.

A basic model for reinforcement learning is as follows:

* A set of States (*S*).
* A set of actions from the set of States (*A*).
* A reward function (*R*).

The trade-off between exploration and exploitation is one of the main features of reinforcement and can greatly affect the performance of a chosen algorithm. Since the goal of reinforcement learning is to maximise the amount of reward gained by an agent; the agent must exploit actions that it has discovered yield a lot of reward. However to find which actions yield a lot of reward the agent must explore actions it has not already used.

Another main feature of reinforcement learning is that the problem in question is taken into context as a whole. This is different from other types of machine learning algorithms, as they will not considered how the results of any sub-problems may affect the problem as a whole.

# Q-Learning

In Q-Learning an agent tries to discover an optimal policy from its history of interactions with the environment.

# Simulation Design

## Simulation Parameters

## Simulation Testing

# Handover Parameter Optimisation

## Approach 1

## Approach 2

## Approach 3

## Results and Comparison

# Future Work

# Conclusions