Handover Optimisation in 4G Systems

Iain Cuthbertson
201015895
Computer & Electronic Systems
University of Strathclyde

April 2014

Abstract

This is the paper's abstract ...

Acknowledgements

Thanks Mum!

Contents

Nomenclature

3G Third Generation

4G Fourth Generation

AI Artificial Intelligence

DL Downlink

eNodeB Evolved Node B

hys Hysteresis

LTE Long Term Evolution

MME Mobility Management Entity

TTT Time to Trigger

UL Uplink

List of Figures

List of Tables

Chapter 1

Introduction

This is time for all good men to come to the aid of their party!

Chapter 2

Related Work

Chapter 3

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.

3.1 Self Organising Network

SON [1]

3.2 Handover Procedure

UE eNodeB MME

3.2.1 Handover Parameters

TTT hys

Parameter	Value(dB)
hys	0.0
	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

Table 3.1: Table of the different LTE hys values.

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

Table 3.2: Table of the different LTE TTT values.

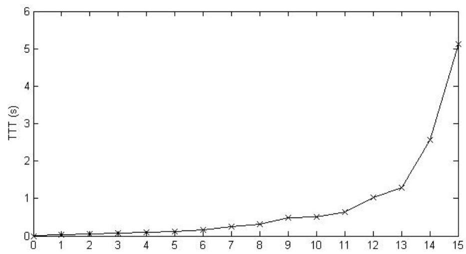

Figure 3.1: Graph of TTT values.

3.2.2 Handover Triggers

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.

Table 3.3: Table of the different LTE Trigger types and their criteria.

[2] [3]

Chapter 4

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. [4] 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 agents 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.

4.1 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. A reinforcement learning algorithm must contemplate this trade-off of whether to exploit an action that resulted in a large reward or to explore other actions with the possibility of receiving a greater reward.

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.

[5]

4.2 Q-Learning

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

$$< s_0, a_0, r_1, s_1, a_1, r_2, s_2, a_2 ... >$$

$$< s, a, r, s' >$$

$$Q[s,a] = (1-\alpha)Q[s,a] + \alpha(r + \gamma max_{a'} Q[s',a']) \tag{4.1}$$

$$Q[s,a] = Q[s,a] + \alpha(r + \gamma max_{a'} Q[s',a'] - Q[s,a]) \tag{4.2}$$

[6]

Chapter 5

Simulation Design

5.1 Simulation Parameters

5.2 Simulation Testing

Chapter 6

Handover Parameter Optimisation

6.1 Approach 1

6.2 Approach 2

6.3 Approach 3

6.4 Comparisons and Results

Chapter 7

Future Work

Chapter 8

Conclusions

We worked hard, and achieved very little.

Bibliography

[1] S. Feng and E. Seidel, "Self-organizing networks (son) in 3gpp long term evolution," *Nomor Research GmbH, Munich, Germany*, 2008.

[2] 3GPP TS 36.331 V10.7.0, *LTE; Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC); Protocol specification (Release 10)*, November 2012.

[3] C. Cox, *An introduction to LTE: LTE, LTE-advanced, SAE and 4G mobile communications*. John Wiley & Sons, 2012.

[4] E. Alpaydin, *Introduction to Machine Learning*. MIT press, 2 ed., 2010.

[5] A. G. Barto and R. S. Sutton, *Reinforcement learning: An introduction*. MIT press, 1998.

[6] D. L. Poole and A. K. Mackworth, *Artificial Intelligence: Foundations of Computational Agents*. Cambridge University Press, 2010.

Appendices

Appendix A

System Design and Evaluation

The contents...