TECHNOLOGICAL UNIVERSITY DUBLIN

MASTERS THESIS

Automated Malware Analysis Using Large Language Models

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A thesis submitted in fulfillment of the requirements
for the degree of M.Sc
in Applied Cybersecurity

in the

School of Informatics and Cyber Security

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Declaration of Authorship

I, Andre M M FARIA, declare that this thesis titled, "Automated Malware Analysis Using Large Language Models" and the work presented in it are my own. I confirm that:

- This work was done wholly or mainly while in candidature for a research degree at this Institute of Technology Blanchardstown.
- Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated.
- Where I have consulted the published work of others, this is always clearly attributed.
- Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work.
- I have acknowledged all main sources of help.
- Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself.

Signed:

Date: February 15, 2025

"The true thesis are the friends we make along the way."

Anonymous

TECHNOLOGICAL UNIVERSITY DUBLIN

Abstract

School of Informatics and Cyber Security

M.Sc

Automated Malware Analysis Using Large Language Models

by Andre M M FARIA

Despite the fact that an abstract is quite brief, it must do almost as much work as the multi-page paper that follows it. In a computer science paper, this means that it should in most cases include the following sections. Each section is typically a single sentence, although there is room for creativity. In particular, the parts may be merged or spread among a set of sentences. Use the following as a checklist for your next abstract (URL: http://www.ece.cmu.edu/ koopman/essays/abstract.html):

Motivation: Why do we care about the problem and the results? If the problem isn't obviously "interesting" it might be better to put motivation first; but if your work is incremental progress on a problem that is widely recognized as important, then it is probably better to put the problem statement first to indicate which piece of the larger problem you are breaking off to work on. This section should include the importance of your work, the difficulty of the area, and the impact it might have if successful.

Problem statement: What problem are you trying to solve? What is the scope of your work (a generalized approach, or for a specific situation)? Be careful not to use too much jargon. In some cases it is appropriate to put the problem statement before the motivation, but usually this only works if most readers already understand why the problem is important.

Approach: How did you go about solving or making progress on the problem? Did you use simulation, analytic models, prototype construction, or analysis of field data for an actual product? What was the extent of your work (did you look at one application program or a hundred programs in twenty different programming languages?) What important variables did you control, ignore, or measure?

Results: What's the answer? Specifically, most good computer architecture papers conclude that something is so many percent faster, cheaper, smaller, or otherwise better than something else. Put the result there, in numbers. Avoid vague, hand-waving results such as "very", "small", or "significant." If you must be vague, you are only given license to do so when you can talk about orders-of-magnitude improvement. There is a tension here in that you should not provide numbers that can be easily misinterpreted, but on the other hand you don't have room for all the caveats.

Conclusions: What are the implications of your answer? Is it going to change the world (unlikely), be a significant "win", be a nice hack, or simply serve as a road sign indicating that this path is a waste of time (all of the previous results are useful). Are your results general, potentially generalizable, or specific to a particular case?

Acknowledgements

The acknowledgments and the people to thank go here, don't forget to include your project advisor...

Contents

List of Figures

List of Tables

List of Abbreviations

LAH	**L**ist **A**bbreviations **H**ere
WSF	**W**hat (it) **S**tands **F**or

Physical Constants

Speed of Light $c_0 = 2.997\,924\,58 \times 10^8\,\mathrm{m\,s^{-1}}$ (exact)

List of Symbols

a	distance	m
P	power	W ($\mathrm{J\,s^{-1}}$)
ω	angular frequency	rad

For/Dedicated to/To my…

Chapter 1

Introduction and Background

1.1 Before You Begin

!!IMPORTANT!!: before you begin this research, be sure that you are familiar with the University's policy on Academic Integrity: https://www.tudublin.ie/explore/about-the-university/academic-affairs/academic-quality-assurance-and-enhancement/academic-integrity/

Also, read the important advice on receiving Feedback, Proofreading and the use of Writing Assistants in Appendix A.1, A.2 & A.3.

1.2 Section Introduction

A thesis is built up of a series of chapters that construct a substantiated and convincing response to the research question(s). Typically, a thesis contains the following chapters: an introduction; a literature review; a description of methodology; a report and discussion of results; and a conclusion. A thesis may have five to eight chapters depending on the nature of the study, the required word count and the requirements of the degree.

1.2.1 About the Introduction Chapter

An introduction is crucial to setting the tone of your thesis – it is the first impression you'll make on your readers (assessors). Briefly, it presents the purpose, context and scope of your research. Likewise, a conclusion is just as crucial – it is the lasting impression you'll make on your readers (assessors). Not only does it give a summary of your thesis, but should provide a clear, convincing answer to your research question(s).

1.2.2 Subsection header 2

After introducing your work, you should list your research questions, hypothesis, and objectives.

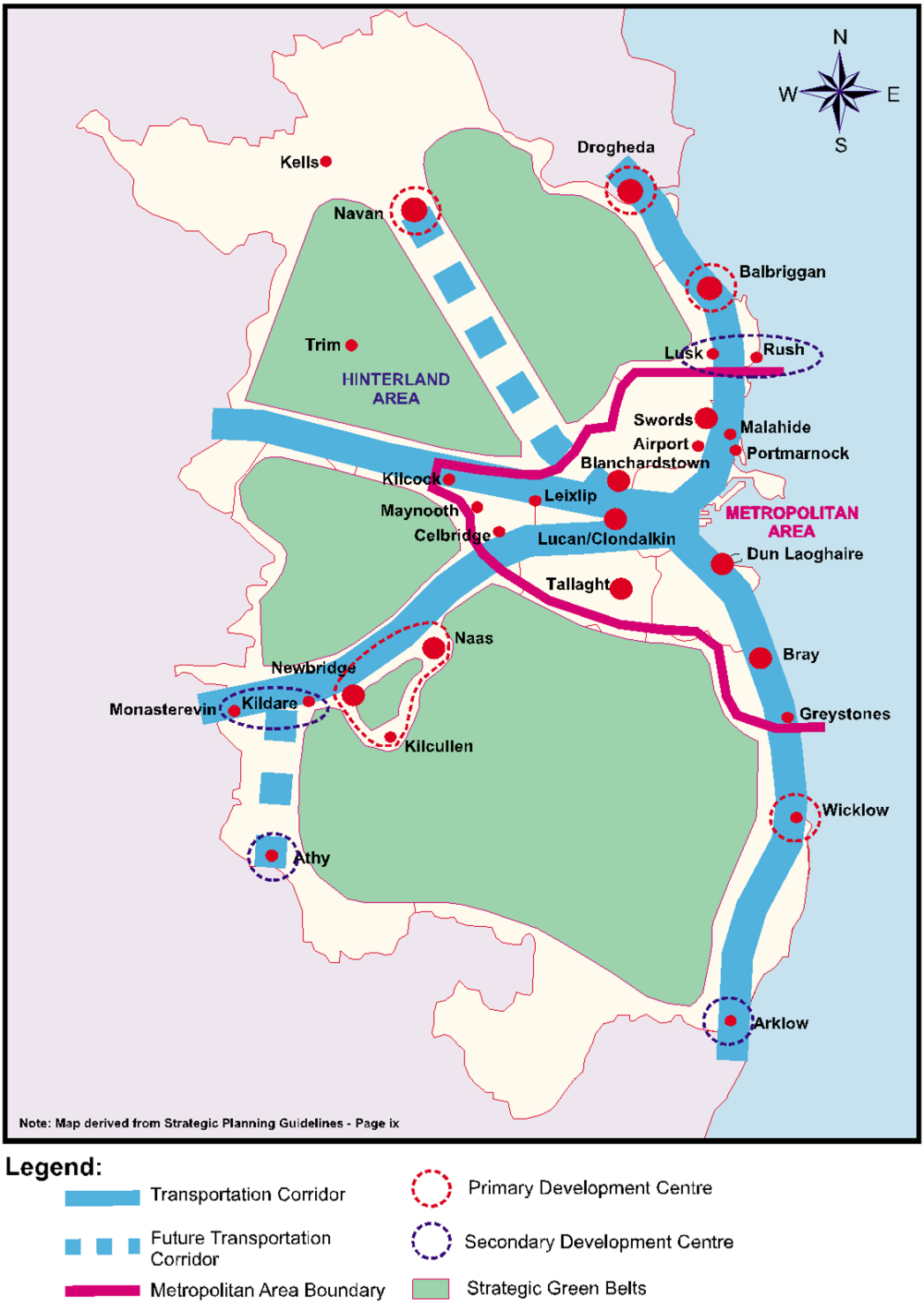
Always keep in mind the meaning of the word "*Thesis*". That is: a thesis is a statement or theory that is put forward as a premise to be maintained or proved. A Hypo*thesis* then, is a sub-thesis, or a smaller part of the overarching thesis.

All of your research questions must aim to prove or disprove your thesis.. and thus your hypotheses.

See more here: https://www.statconsul.com/research-questions.php

1.2.3 Subsection header 3

The last thing you do in an Introduction Chapter is to outline the contents of your thesis, i.e., a review of then literature is provided in Chapter 2, starting with... etc... Chapter 3 provides a description of the method... etc...



1.3 More about the Introduction chapter

The introduction allows you to orient the reader to your research project and preview the organisation of your thesis. In the introduction, state what the topic is about, explain why it needs to be further researched and introduce your research question(s) or hypothesis.

Whilst patterns of organisation in introductions vary, there are some common features that will help you to achieve an informative and engaging introduction. Let's identify these features:

- Introduce the topic
- Define key terms and concepts
- Give background and context for the topic (this may include a brief literature review)
- Review and evaluate the current state of knowledge in the topic (this may include a brief literature review)
- Identify any gaps, shortcomings and problems in the research to date
- Introduce your research question(s) or hypothesis
- Briefly describe your methodology and/or theoretical approach
- Explain the aim of your research and what contribution it will make to the topic
- Give an overview of the chapter outline of the thesis.

It's important to note that, depending on your field of study and the faculty requirements of your thesis, not all of these features will be relevant. Also, these features may occur in varied orders.

Most people write many drafts of their introduction. It can be useful to write one early in the research process to clarify your thinking. You will need to write a version for your confirmation proposal and other milestones. As your research progresses and your ideas develop, you will need to revise it. When the final draft of chapters is complete, check the introduction once more to make sure that it accurately reflects what you have actually done.

Chapter 2

Literature Review

2.1 What is a Literature Review?

A literature review is a section of your thesis or dissertation in which you discuss previous research on your subject. Following your Introduction chapter, your literature review begins as you try to answer your larger research question: Who has looked at what, why, and what have they found? It allows you to understand what others have said about your topic, to verify your assumptions, to refine your initial research question, and to identify gaps. For your readers, the literature review also demonstrates that you are knowledgeable about related research and scholarly traditions in your field.

2.1.1 Preparing to Write

The literature review is more than just a list of previous research papers in the field. If you think of writing a thesis or dissertation as writing a story of your research, the literature review then will be a story within a story. In the literature review story, you tell the reader about general trends, traditions, and approaches to your subject, ones that surround and support your study.

Choose texts to help you try to answer your research question. As you explore the literature, take notes:

- Why did you pick up this text? [Reminder: What is being studied, by whom, why? What did they find? As you pick up a text, note all documentation information.]
- How does this article, chapter, book, study help you answer your question or not?
- When you find a publication of interest, read the Abstract to see if it is what you are looking for. If not, discard the text. If it does seem to be what you are looking for, then glance over the Introduction and Conclusions. Again, if it is what you are looking for, you can now invest the time to read the entire publication, or the section of the publication that interests you. This method save a lot of time in the long term.
- Be sure that all publications are from a credible source: You can gauge this by where an article/book has been published, if it has been peer reviewed, how it has ben written, how many times it has been cited etc...

After you have read and written, draw a diagram, chart, or matrix that would help you to visualize connections between your sources and reveal a possible structure for your literature review. Some researcher like to print papers and organise

content with colour (with highlighters and post-it notes), others like to use tools such as *NVivo*. This approach allows you to notice distinct patterns in the literature, e.g., how an algorithm has developed over time. You may choose to plot it out on a timeline. Or, you may decide to organize your literature review by the researchers' stance towards your subject. Or, you may want to create a sort of bubble map to discover:

- What major trends and patterns in the results of previous studies emerge?
- What common threads do you find?
- How do these studies connect?

There is no right or wrong way for structuring the review. It should explain the thinking process behind your choices and help reveal the need to answer your question (to fill a gap) and how to go about doing that (the methodology).

When you have a rough draft completed, ask yourself:

- What previous research has been more significant and less significant?
- What gaps in literature have you noticed? Why do these gaps exist?
- How might your research hypothesis or research questions inform your organization and characterization of the previous literature?

2.1.2 Revising

When describing, critiquing, and citing your sources, use the following citation patterns to introduce and comment on sources:

- Generalisation (combining 2 or more sources): Describe what makes this group of sources a category
- Summarise each key source; paraphrase the author[s]' argument (this is not plagiarism because you are citing the work).
- Try to avoid using quotations to note key words or phrases... better not to overuse this strategy and to use your own words where possible.
- Use block quotations (more than 40 words) sparingly.

However, avoid ambiguous citations like these two:

In the example above, it is not clear whether Clement and Lee are major researchers in their fields or what their work includes. Also, one author does not suggest "wide investigation" or "much" research. Best to use multiple sources for broad statements like these.

Help your readers make their way through your literature review by referring to its organization or back to a part of the review, or by providing a definition. For example, use words and phrases, such as *In this section, I will discuss ...*
This part will describe ...
For the purpose of this discussion, metadiscourse means ...
The main purpose of this review has been ...
Thus far, this review has outlined ...

Things to Remember

- Avoid describing each piece of relevant research in detail, piece by piece.
- Focus on general trends and approaches.
- Only critique the few most relevant, seminal sources. There is no need to critique each source.
- When reviewing a study, avoid reporting an author's assertions as though they were findings.
- Highlight agreement before disagreement.
- Depending on your field of study, you may want to tell a story that led you to this research and would help explain your choices to include or exclude previous research.

2.1.3 Sources

They Say/I Say: The Moves That Matter in Academic Writing by Gerald Graff and Cathy Birkenstein Academic Writing for Graduate Students and Telling a Research Story: Writing a Literature Review by Christine B. Feak and John M Swales
https://www.jsums.edu/wrightcenter/files/2016/03/Writing-a-Literature-Review.pdf

2.1.4 Citing and Referencing

This Latex template uses the 'natbib' package to manage references and citations. There is a good introduction to this package here: https://www.overleaf.com/learn/latex/Bibliography_management_with_natbib

Note: there are different referencing styles, these can be set in the main thesis.tex file. Find out which style you should use from your project documentation, project coordinator or supervisor.

It is important to note that when referencing in-text, you should format the citation differently depending on how you reference the author. Consider the following sentence:

"*Smith, 2023 explores the use of Association Rules Mining to identify patterns in a sign language dataset.*"

You will note that when Smith's 2023 publication is referenced directly in the text, only the year of the publication is in brackets, i.e., the authors name is not in brackets.

"*The use of Association Rules Mining to identify patterns in a sign language dataset has been explored recently (Smith, 2023) .*"

When the same publication is referenced indirectly at the end of the sentence, the authors name and year of publication are inside the brackets. See the following reference sheet to help you keep track of this: https://gking.harvard.edu/files/natnotes2.pdf

Chapter 3

Methodology

3.1 What is a Methodology?

Every thesis, regardless of the discipline and field of inquiry it relates to, needs to answer these questions:

- How did you do your research?
- Why did you do it that way?

This covers not only the methods used to collect and analyse data, but also the theoretical framework that informs both the choice of methods and the approach to interpreting the data. In some disciplines, the approach to knowledge underpinning both the type of research questions asked and the methods chosen to answer them is called "methodology", and needs to be articulated. Both methods and theoretical approach relate explicitly to the research question(s) addressed in the thesis.

You may need to summarise available methods and theoretical approaches for your research topic; you will certainly need to justify your choice of method(s). If you apply a combination of methods you'll need to justify why you chose such an approach. Your explanation should also indicate any reliability or validity issues concerning the data, and discuss any ethical considerations that arise from your choices.

Whilst patterns of organisation in a methods chapter may vary, there are some common elements that you'll need to include to achieve an informative chapter. Let's identify these features:

- place or setting of the research
- duration of the study and other time related factors
- study design – e.g. an outline of the research stages including instruments and techniques
- specifics of the participants, materials, etc.
- sampling frameworks (e.g. criteria, size, scope, etc.)
- any inclusions/exclusions
- outcome measurement procedures (e.g. statistical tests, comparisons, etc.)
- consent and ethics committee approval
- theoretical basis of the research

- data management

While most of these elements will be relevant to your methods chapter, you'll find that there are discipline specific elements and requirements. The detail and emphasis of what is covered in a discussion of methods/methodology will be different in different disciplines.

3.1.1 STEM specific Method Chapter

Key features of method descriptions in STEM disciplines include:

- demonstration of fit between methods chosen and research question(s)
- rationale for choosing materials, methods and procedures
- details of materials, equipment and procedures that will allow others to:
  - replicate experiments
  - understand and implement technical solutions

Chapter 4

Discussion of Results

4.1 Section Introduction

The reporting and discussion thesis chapters deal with the central part of the thesis. This is where you present the data that forms the basis of your investigation, shaped by the way you have interpreted it and developed your argument or theories about it. In other words, you tell your readers the research story that has emerged from your findings. These chapters will form the bulk of your complete thesis. Before you even begin writing up the reporting and discussion chapters, you'll need to undertake some thinking and planning.

There is quite a loot to say about this topic so Ive provided a like here for further reading: https://www.monash.edu/student-academic-success/excel-at-writing/how-to-write/thesis-chapter/reporting-and-discussion-thesis-chapters

Chapter 5

Conclusion

5.1 About Conclusions

Depending on the type of research presented in the thesis, conclusion chapters or sections tend to include at least some of the following:

- A clear answer to your research question or hypothesis
- Summary of the main findings or argument
- Connections between your findings or argument to other research
- Explanation and significance of the findings
- Implications of the findings
- Limitations of the research and methodology
- Recommendations for future research

Your conclusion chapter is the place to emphasise the new knowledge that you've contributed to the field of study and explain its significance. This chapter is your opportunity to leave a strong impression on the reader (assessors) about the strength and relevance of your research, and your skills as a researcher.

Importantly, the conclusion chapter must link with your introduction chapter to complete the framing of the thesis and demonstrate that you have achieved what you set out to do.

Appendix A

Frequently Asked Questions

A.1 Getting Feedback

1. Get feedback **often** and from different audiences – your family, friends, professors, colleagues, advisor, other graduate students. The more you talk about your research, the more comfortable you get with it.

2. Keep a positive attitude. Research is hard. If it were easy, everyone would be doing it.

3. Consider setting up or joining a thesis group to share your ideas and experiences.

Supervisor's feedback

Some supervisors will ask for you to send each chapter as you complete it, offering feedback at that point, and then again at the end when the thesis chapters are collated. Other supervisors may want to be more involved, and there are others who will not want to see your thesis until it is completed by your standards. Whichever approach your supervisor takes, be aware that they will need some time to read through your work and provide feedback. Your thesis review is likely not the only piece of work your supervisor is undertaking, so be patient and factor review time into your work schedule.

A couple of points to note about supervisor feedback:

- You will receive feedback on your approach to research (i.e., method, experiment design etc...) as well as your writing. It is your responsibility to take notes at meetings etc. in order to record this feedback. It is also up to you whether or not you act upon the feedback provided.

- Your supervisor's role is to guide your work. It is not their job to complete the research, suggest methods, design experiments, or to write/rewrite sections of your thesis.

- Your supervisor should be supportive but sometimes their feedback may be difficult to hear. Just remember, their goal is to guide you and to make you a better researcher. Learn to have your work criticised in a constructive manner, it is part of the learning process.

- It is not the role of your supervisor to proofread your thesis. Many supervisors will point out typos, grammatical errors or styling issues etc. when they see them, but this is not their role.

A.2 Proofreading/copyediting

It is important to have your work proofread[1]. If English is not your first language, this is even more important for you.

How?

A good approach is to proofread yourself as you write and then again when you are finished writing a section or chapter. When you have a near final draft, have it proofread by a friend, family member, colleague, or a classmate etc... (not your supervisor). Choose your proofreader wisely. Make sure that they have good written English skills and are able to spot grammatical errors. A native English speaker can be good for this but not all native English speakers have the skills needed to be a good proofreader.

There are many things to look out for when reviewing your own work, everything from text alignment and section numbering, to figures and tables, to spelling and grammar. It's best to identify and fix any of these errors immediately. Don't wait until the end because these will build up and it often takes longer than you think to fix them.

If you find that you make the same mistake regularly, e.g., you misspell the same word regularly, or you use a colon where you shouldn't, then make a list of these to check back when you are finished each section (the search feature is good for this).

[1] Two types of editing that are commonly used interchangeably are copy editing and proofreading. Both types of editing clean up writing, but each has its distinct contribution to the process. https://thesiswhisperer.com/2016/11/30/doing-a-copy-edit-of-your-thesis/

A.3 Writing Assistants

In the past, students may have used tools such as Grammarly or Quetext, but this has become more problematic because such editing tools now come with AI assisted writing (see more here: https://tudublin.libguides.com/c.php?g=720901&p=5233062).

Using tools such as a spell checker, a grammar checker, and a punctuation checker are generally acceptable. Using more advanced tools to rewrite sentences, check tone, offer alternative word choices, offer citations etc... is not acceptable.

If in doubt don't use any such software. In general, it appears that, as of 2025, the free version of Grammarly is fine to use, but the pro version is not.

A.4 Example of Longtable

Ticket Type ID	Description
300	Feeder Ticket - Child
301	Feeder Ticket - Adult
310	10-Journey Feeder - Adult
317	Airlink Adult Airport-Busarus
318	Airlink Child Airport-Busarus
319	Airlink Child Airport-Heuston
320	Airlink Adult Airport-Heuston
333	Adult Single Feeder
365	Child Bus/Rail Short Hop - Day
366	Adult Bus/Rail Short Hop - Day
367	Family Bus/Rail Short Hop - Day
369	4 Day Explorer
410	Weekly Adult Short Hop Bus/Rail
430	Weekly Adult Medium Hop Bus/Rail
431	Weekly Adult Long Hop Bus/Rail
432	Weekly Adult Giant Hop Bus/Rail
433	Monthly Adult Short Hop Bus/Rail
455	Monthly Adult Long Hop Bus/Rail
456	Monthly Adult Giant Hop Bus/Rail
457	Monthly Student Short Hop Bus/Rail
458	Annual Bus/Rail
478	Annual All CIE Services
479	Annual CIE Pensioner Bus/Rail
480	Monthly CIE Pensioner Bus/Rail
493	Foreign Student - 1 Week
494	Foreign Student - 2 Week
495	Foreign Student - 3 Week
496	Foreign Student - 4 Week
497	CYC Group
600	Adult Cash Fare
608	Nitelink (Maynouth/Celbridge)
609	Nitelink (Maynouth/Celbridge)
610	Child Cash Fare
620	Schoolchild Cash Fare
625	Adult (formerly Shopper)
630	Adult 10-Journey (3 Stages)
631	Adult 10-Journey (7 Stages)
632	Adult 10-Journey (12 Stages)
633	Adult 10-Journey (23 Stages)
634	Adult 10-Journey (23+ Stages)
640	Adult 2-Journey (3 Stages)
641	Adult 2-Journey (7 Stages)
642	Adult 2-Journey (12 Stages)
643	Adult 2-Journey (23 Stages)
644	Adult 2-Journey (23+ Stages)
650	Schoolchild 10-Journey
651	Scholar 10-Journey
652	Schoolchild 2-Journey
653	Scholar 2-Journey
657	Transfer 90 (or Passenger Change)
658	Adult Single Heuston-CC
660	Adult One Day Travelwide
661	Child One Day Travelwide
662	Family One Day Travelwide
665	Rambler (3 Day Bus only)
670	Weekly Adult Bus

Ticket Type ID	Description
671	Weekly Adult Cityzone
690	Weekly Student Travelwide
691	Weekly Student Cityzone
705	Monthly Adult Citizone (AerLingus.)
710	Monthly Adult Travelwide
730	Annual Adult Travelwide
760	Annual Staff Bus
790	School Pass
791	OAP Pass
800	City Tour - Adult
801	City Tour - Family
802	City Tour - Child
898	10 - Journey Test Ticket

Bibliography

Smith, Robert G. (2023). “Exploiting Association Rules Mining to Inform the Use of Non-Manual Features in Sign Language Processing”. PhD thesis. Technological University Dublin, Ireland.