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Student name



Thesis presented in partial fulfilment of the requirements for the degree of  
**Master of (Industrial) Engineering**  
in the Faculty of Engineering at Stellenbosch University

Supervisor: Supervisor name  
Co-supervisor: Co-supervisor name

December 2015



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# Abstract

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# Uittreksel

Skryf jou Afrikaanse uittreksel hier.





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# Acknowledgements

The author wishes to acknowledge the following people and institutions for their various contributions towards the completion of this work:

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# Glossary

**Something** Description of that something.

**Something** Description of that something.

**Something** Description of that something.



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# List of Reserved Symbols

Symbols in this thesis conform to the following font conventions:	
$A$	Symbol denoting a <b>some general thing</b> (Roman capitals)
$\mathcal{A}$	Symbol denoting a <b>some general thing</b> (Calligraphic capitals)

Symbol	Meaning
$\times$	Symbol used to denote the multiplication operator
$\times$	Symbol used to denote the multiplication operator
$\times$	Symbol used to denote the multiplication operator
$\times$	Symbol used to denote the multiplication operator
$\times$	Symbol used to denote the multiplication operator





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# List of Acronyms

**WISF:** What It Stands For

**WISF:** What It Stands For

**WISF:** What It Stands For



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# List of Algorithms

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## CHAPTER 1

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# Introduction

### Contents

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### 1.1 Background

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## 1.2 Informal problem description

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## 1.3 Research hypothesis

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## 1.4 Scope and objectives

The following objectives will be pursued in this project/thesis/dissertation:

- I To *conduct* a thorough survey of the literature related to:
  - (a) facility location problems in general,
  - (b) models for the placement of a network of radio transmitters in particular,
  - (c) the nature of parameters required to describe effective radio transmission, and
  - (d) terrain elevation data required to generate an instance of the bi-objective radio transmitter location problem described in the previous section.
- II To *establish* an suitable framework for evaluating the effectiveness of a given set of placement locations for a network of radio transmitters in respect of its total area coverage and its mutual area coverage.
- III To *formulate* a bi-objective facility location model suitable as a basis for decision support in respect of the location of a network of radio transmitters with a view to identify high-quality trade-offs between maximising total coverage area and maximising mutual coverage area. The model should take as input the parameters and data identified in Objective I(c)–(d) and function within the context of the framework of Objective II.

- IV To *design* a generic *decision support system* (DSS) capable of suggesting high-quality trade-off locations for user-specified instances of the bi-objective radio transmitter location problem described in the previous section. This DSS should incorporate the location model of Objective III.
- V To *implement* a concept demonstrator of the DSS of Objective IV in an applicable software platform. This DSS should be flexible in the sense of being able to take as input an instance of the bi-objective radio transmitter location problem described in the previous section via user-specification of the parameters and data of Objectives I(c)–(d) and produce as output a set of high-quality trade-off transmitter locations for that instance.
- VI To *verify* and validate the implementation of Objective V according to generally accepted modelling guidelines.
- VII To *apply* the concept demonstrator of Objective V to a special case study involving realistic radio transmission parameters and real elevation data for a specified portion of terrain.
- VIII To *evaluate* the effectiveness of the DSS and associated concept demonstrator of Objectives IV–VI in terms of its capability to identify a set of high-quality trade-off solutions for a network of radio transmitter locations.
- IX To *recommend* sensible follow-up work related to the work in this project which may be pursued in future.

## 1.5 Research methodology

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## 1.6 Project/thesis/dissertation organisation

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## CHAPTER 2

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# Tables

Results for $\mathcal{P}_n \square \mathcal{P}_n$				Results for $\mathcal{H}_{n,n}$			
$n$	LP	$\gamma_s$	Time	$n$	LP	$\gamma_s$	Time
2	1.33	2	0.01	2	1.00	2	0.01
3	2.50	4	0.02	3	2.00	3	0.01
4	4.00	7	0.07	4	4.00	5	0.04
5	6.27	9	0.17	5	5.00	7	0.08
6	8.75	13	0.39	6	6.00	10	0.27
7	11.50	18	2.90	7	9.00	13	7.41
8	14.81	23	72.16	8	11.33	17	110.00
9	18.25	29	23 356.24	9	13.50	21	1 083.17
10	22.39	35*	TO	10	16.86	27 <sup>†</sup>	MO

TABLE 2.1: *Each table must be supplied with a long caption, making the table stand-alone (e.g. describing the meaning of all symbols, rows and columns), ended with a full-stop.*

		this goes across 6 columns					
		col a	col b	col c	col d	col e	col f
this is sideways, and goes across six rows	row 1						
	row 2						
	row 3						
	row 4						
	row 5						
	row 6						

TABLE 2.2: *Type full caption here.*

$n \rightarrow$	2	3	4	5	6	7	8	9
$ \mathcal{S}_n^0 $	1	2	6	17	81	514	5 460	107 794
$ \mathcal{S}_n^1 $		1	3	10	51	355	4 205	94 106
$ \mathcal{S}_n^2 $			1	4	16	136	2 050	52 502
$ \mathcal{S}_n^3 $				2	5	32	551	16 923
$ \mathcal{S}_n^4 $					2	5	70	3 081
$ \mathcal{S}_n^5 $						1	6	245
$ \mathcal{S}_n^6 $							3	13
$ \mathcal{S}_n^7 $								3
Total	1	3	10	33	155	1 043	12 345	274 667
Time		$\ll 1$	$< 1$	1	15	374	15 895	1 069 220

TABLE 2.3: *Type full caption here.*

---

## CHAPTER 3

---

# Figures

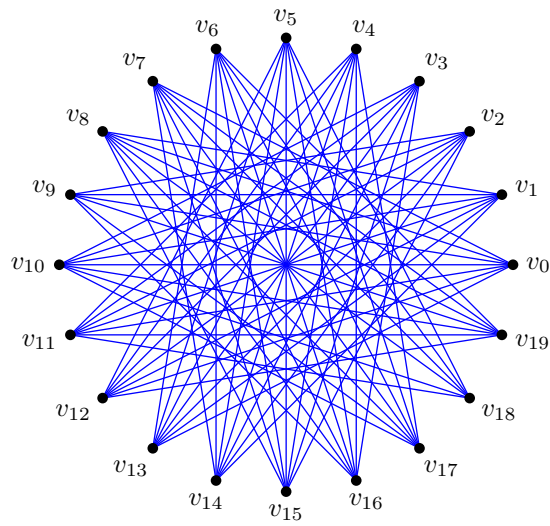


FIGURE 3.1: *Each figure must be supplied with a long caption, making the figure stand-alone and ended with a full-stop.*

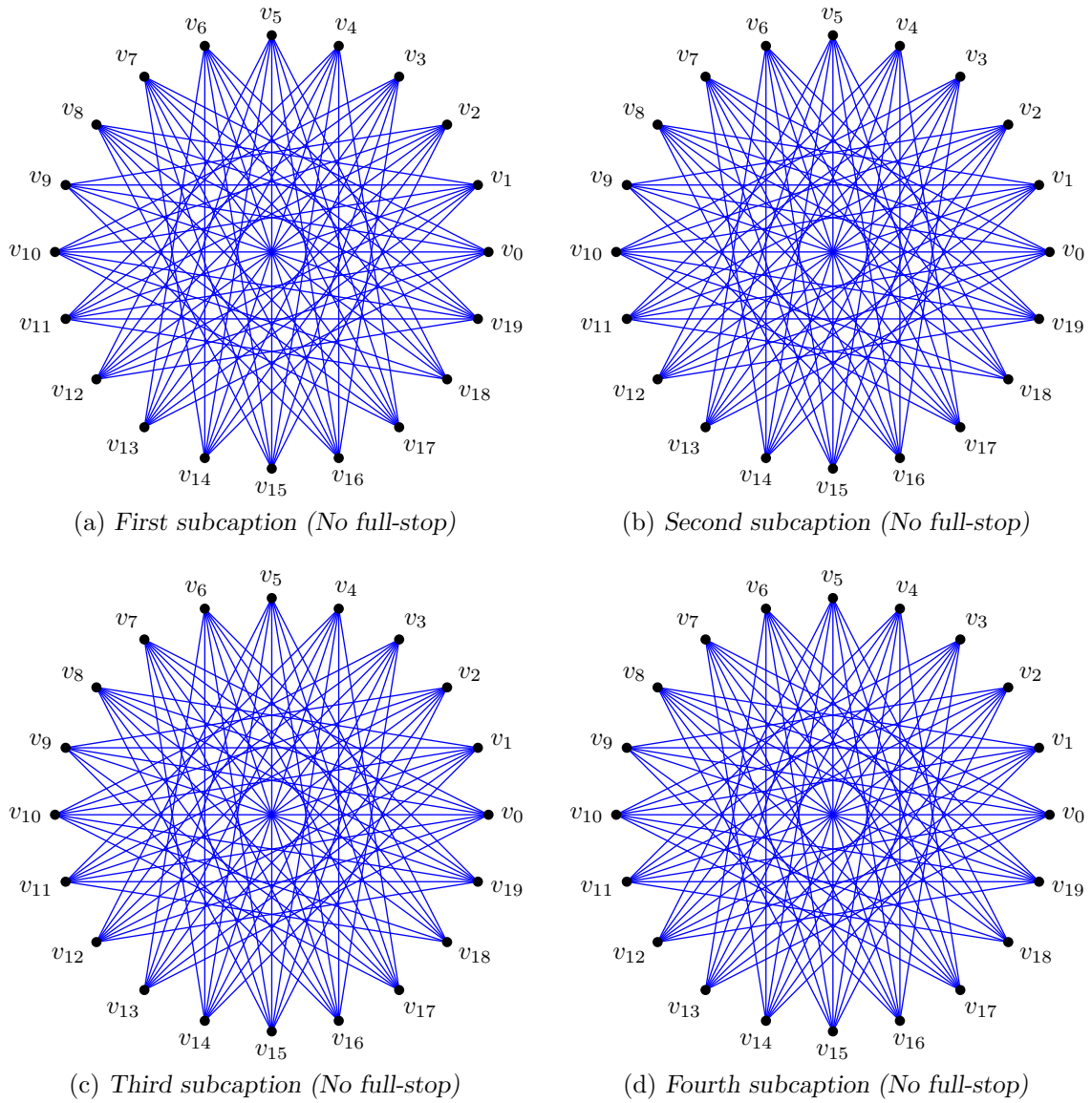


FIGURE 3.2: End the main caption with a full-stop, but not each of the sub-figure captions!

The subfigures are Figures 3.2(a), 3.2(b), 3.2(c) and 3.2(d).



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## CHAPTER 4

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# Algorithms

---

**Algorithm 4.1:** Algorithm example

---

**Input** : Description of the input to the algorithm.

**Output:** Description of the output from the algorithm.

```
1 special treatment of the first line;
2 for  $i \leftarrow 2$  to  $l$  do
3   special treatment of the first element of line  $i$ ;
4   for  $j \leftarrow 2$  to  $w$  do
5      $\text{left} \leftarrow \text{FindCompress}(Im[i, j - 1]);$ 
6      $\text{up} \leftarrow \text{FindCompress}(Im[i - 1,]);$ 
7      $\text{this} \leftarrow \text{FindCompress}(Im[i, j]);$ 
8     if left compatible with this then
9       if  $\text{left} < \text{this}$  then  $\text{Union}(\text{left}, \text{this});$ 
10      else  $\text{Union}(\text{this}, \text{left});$ 
11     if up compatible with this then
12       if  $\text{up} < \text{this}$  then  $\text{Union}(\text{up}, \text{this});$ 
13       else  $\text{Union}(\text{this}, \text{up})$ 
14   foreach element  $e$  of the line  $i$  do  $\text{FindCompress}(p)$ 
```

---

**Algorithm 4.2: DefendTree**


---

**Input** : A tree  $T$  represented by an array  $\text{Parent}[1, \dots, n]$ .  
**Output**: A minimum secure dominating set of  $T$ , represented by a boolean array  $X$ .

```

1 for  $i \leftarrow 1$  to  $n$  do
2    $\text{A3Label}[i] \leftarrow \text{FALSE}$ ;
3    $X[i] \leftarrow \text{FALSE}$ ;
4    $\text{Labels}[i] \leftarrow [0, 0, 0, 0, 0, 0, 0]$ ;
5   if vertex  $i$  is a anchor of  $T$  then  $\text{Branch}[i] \leftarrow \text{TRUE}$ ;
6    $\text{Previous1Label}[i] \leftarrow 0$ ;
7 for  $i \leftarrow n$  down to 2 do
8    $\ell \leftarrow \text{EffectiveLabel}(\text{Labels}[i])$ ;
9   if  $\ell$  is odd then  $X[i] \leftarrow \text{TRUE}$ ;
10   $\text{Labels}[\text{Parent}[i], \ell(i) + 1 \pmod{7}] ++$ ;
11  if  $\ell = 2$  and  $\text{Branch}[\text{Parent}[i]]$  then
12     $\text{A3Label}[\text{Parent}[i]] \leftarrow \text{TRUE}$ ;
13     $\text{prev} \leftarrow \text{Previous1Label}[\text{Parent}[i]]$ ;
14    if  $\text{prev} > 0$  then  $X[\text{prev}] \leftarrow \text{TRUE}$ ;
15  if  $\ell = 0$  and  $\text{Branch}[\text{Parent}[i]]$  then
16    if  $\text{A3Label}[\text{Parent}[i]]$  then
17       $X[i] \leftarrow \text{TRUE}$ ;
18    else
19       $\text{prev} \leftarrow \text{Previous1Label}[\text{Parent}[i]]$ ;
20      if  $\text{prev} > 0$  then  $X[\text{prev}] \leftarrow \text{TRUE}$ ;
21       $\text{Previous1Label}[\text{Parent}[i]] \leftarrow i$ ;
22  $\ell \leftarrow \text{EffectiveLabel}(\text{Labels}[1])$ ;
23 if  $\ell$  is odd then  $X[1] \leftarrow \text{TRUE}$ ;
24 if  $\text{Labels}[1, j] = 0$  for  $j = 1, 3, 4, 5, 6$  then  $X[1] \leftarrow \text{TRUE}$ ;
25 if  $\text{Labels}[1, j] = 0$  for  $j = 1, 3, 5, 6$  and  $\text{Labels}[1, 0] \geq |\text{Labels}[1] - 1|$  then  $X[1] \leftarrow \text{TRUE}$ ;
26 if  $\ell = 3$  then
27    $\text{prev} \leftarrow \text{Previous1Label}[1]$ ;
28   if  $\text{prev} > 0$  then  $X[\text{prev}] \leftarrow \text{TRUE}$ ;
29 return  $X$ ;

```

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## CHAPTER 5

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# Conclusion

### Contents

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### 5.1 Project/thesis/dissertation summary

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## 5.2 Appraisal of project/thesis/dissertation contributions

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## 5.3 Suggestions for future work

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## 5.4 What the student has learnt during this project

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[\* ]

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## APPENDIX A

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# Project Timeline

The expected timeline is given in Figure A.1 in Gantt-chart form.

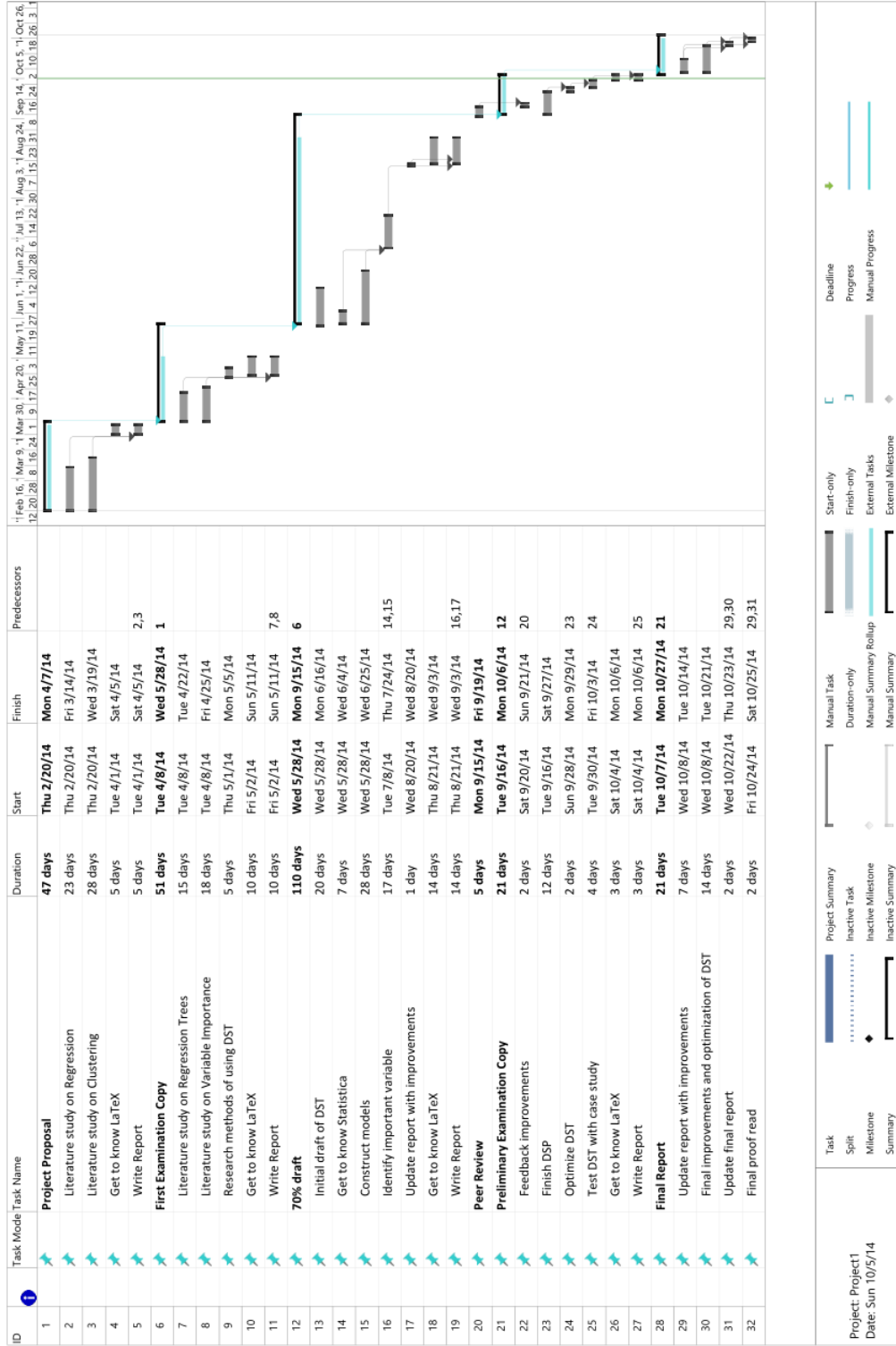


FIGURE A.1: Expected timeline in Gantt-chart form.

---

# APPENDIX B

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## Data

Data related to the Case Study in Chapter 5 are presented in Table B.1.

		this goes across 6 columns					
		col a	col b	col c	col d	col e	col f
this is sideways, and goes across six rows	row 1						
	row 2						
	row 3						
	row 4						
	row 5						
	row 6						

TABLE B.1: *Type full caption here.*