Visitor flows in zoos and amusements parks a case study in Apenheul

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OR & Traffic

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≻Spider monkeys			
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➤Research question	# people	7	≠ people
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>Squirrel monkeys (2)		
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Apenheul

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 ≻Apenheul >Apenheul: busy & guiet days 	Some monkeys walk around freely
 >Problem & causes >Squirrel monkeys (1) >Squirrel monkeys 	Other monkeys live on islands
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Apenheul

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≻Squirrel monkeys

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≻Spider monkeys
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Zoo with primarily monkeys and apes

Some monkeys walk around freely

Other monkeys live on islands

450000 visitors each year

Quiet days: less than 100 visitors

Busy days: more than 5000 visitors

Apenheul: busy & quiet days



Apenheul: busy & quiet days



Problem & causes

Introduction >(Too) crowded? >Apenheul >Apenheul: busy & guiot days	Problem: on busy days it can be very busy in some areas, while other areas are still relatively quiet.
 >Problem & causes >Squirrel monkeys (1) 	Causes:
≻Squirrel monkeys (2)	Feeding sessions
 ≻Spider monkeys ≻Effects > Descent exception 	Some areas are more appealing than others:
Possible measures	Areas with monkeys walking around freely
Data collection and analysis	Lookouts
Scenarios and models	Areas with less animals
Conclusions	

Squirrel monkeys (1)



Squirrel monkeys (2)



Spider monkeys



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Effects

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>Squirrel monkeys (2)
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Congestion in the more appealing areas

Monkeys do not like the crowd and shy away from the visitors

Visitors have to wait (because of the crowdedness) and moreover, do not see that many monkeys

Effects

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Congestion in the more appealing areas

Monkeys do not like the crowd and shy away from the visitors

Visitors have to wait (because of the crowdedness) and moreover, do not see that many monkeys

 \Rightarrow Visitors are displeased

Research question

Introduction ≻(Too) crowded?	Improve the physical flow of visitors such that:
≻Apenheul ≻Apenheul: busy & quiet days	The relatively busy areas become quieter
 ≻Problem & causes ≻Squirrel monkeys (1) 	The relatively quiet areas become busier
≻Squirrel monkeys (2)	
≻Spider monkeys	
≻Effects	
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_models	Possible measures
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(Im)possibilities

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Apenheul cannot ...

◆ . . . command visitors to take a certain route

...command visitors to stay in a certain area

... command visitors to go to another area

(Im)possibilities

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≻Measures (2)

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Apenheul cannot ...

◆ ... command visitors to take a certain route

• . . . command visitors to stay in a certain area

.... command visitors to go to another area

Apenheul can manipulate visitors to stay longer, take a certain route or move to the next area using measures

Measures (1)

.	
Introd	luction
	action

- Possible measures
- ≻(Im)possibilities
- ≻Measures (1)
- ≻Measures (2)
- Data collection and analysis

Scenarios	and
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Expand capacity

- Expand until all areas are not crowded anymore
- Expand until the largest problems are solved



Measures (1)

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≻(Im)possibilities

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≻Measures (2)

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Expand capacity

Routing

• Expand until all areas are not crowded anymore

Expand until the largest problems are solved

Two routes with advise on which to take

Two routes without advise on which to take

Measures (2)

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- Possible measures
- ≻(Im)possibilities
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- ≻Measures (2)

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Feeding sessions schedule

Every hour

◆ Every 1 and 2 hours

Every 2 hours simultaneously

Every 2 hours not simultaneously

Measures (2)

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- Possible measures
- ≻(Im)possibilities
- ≻Measures (1)
- ≻Measures (2)

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Feeding sessions schedule

Every hour

◆ Every 1 and 2 hours

Every 2 hours simultaneously

Every 2 hours not simultaneously

■ Make quiet areas more attractive

With help of feeding sessions

With help of new attractions

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 ≻Readers and areas ≻Visitor preferences(1) >Visitor preferences(2) >Visitor preferences(3) 	
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Visitors get a monkeyproof bag when entering

Chips are put in some of those bags

Readers are at some places in the park

Visitors are (anonymously) tracked

Data collection

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≻Map of Apenheul

- ≻Schematic map
- ≻Readers and areas
- ≻Visitor
- preferences(1)
- ≻Visitor
- preferences(2)
- ≻Visitor
- preferences(3)

Scenarios and models

Conclusions

Visitors get a monkeyproof bag when entering

- Chips are put in some of those bags
- Readers are at some places in the park
- Visitors are (anonymously) tracked

Problems:

- Some readers did not work properly
- Some visitors were within the reach of two readers at the same time

 Some visitors were in the park before opening hours (daylight saving time)



Map of Apenheul

8 Introduction Possible measures Data collection and analysis ≻Data collection ≻Map of Apenheul h ≻Schematic map ≻Readers and areas ≻Visitor 5 preferences(1)4 ≻Visitor preferences(2) ≻Visitor preferences(3) Scenarios and models Conclusions

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Schematic map of Apenheul



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Schematic map of Apenheul



Schematic map of Apenheul



Readers and areas



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Visitor preferences: visitor routes

Introduction	■ 1015 unique (groups of) visitors				
Possible measures					
Data collection and analysis	■ 326 different routes				
≻Data collection					
≻Map of Apenheul	The majority follows the indicated route				
≻Schematic map	Ine majority follows the multated foute				
 Readers and areas Visitor preferences(1) Visitor preferences(2) Visitor preferences(3) Scenarios and 					
models					
Conclusions					

Visitor preferences: visiting times

Introduction			Standard	Number
Possible measures	Area	Average	deviation	of visits
Data collection and analysis	Squirrel monkey forest	15.5	11.96	1618
 Data collection Map of Apenheul Schematic map Readers and areas Visitor preferences(1) 	World's forest	6.0	6.19	2440
	Crossroads baobab	5.6	10.12	1790
	Madagascar forest	9.8	9.97	1274
➤Visitor preferences(2)	Dajak area	39.5	21.25	1189
≻Visitor	Orang utan area	13.9	9.10	1088
Scenarios and models Conclusions	Barbary macaque area	9.8	6.05	1070
	Gorilla island passage	14.0	10.44	1070
	Children's playjungle	11.1	16.50	1086
	Forest hill	20.2	16.10	1098
	Woolly monkey plaza	11.1	10.73	1283
Visitor preferences: visiting times

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	Woolly monkey plaza	11.1	10.73	1283

Visitor preferences: feeding sessions

Introduction	Visiting times during	outside feeding s	essions:
Possible measures			
Data collection and analysis ≻Data collection		During feeding	Outside feeding
≻Map of Apenheul	Area	(# visits)	(# visits)
 ➤Schematic map ➤Readers and areas 	Squirrel monkey forest	31.4 (203)	11.0 (818)
≻Visitor preferences(1)	Madagascar forest	29.6 (80)	7.0 (824)
≻Visitor preferences(2)	Orang utan area	24.9 (45)	12.9 (889)
≻Visitor preferences(3)	Gorilla island passage	31.7 (38)	13.4 (809)
Scenarios and models	Woolly monkey plaza	32.1 (43)	9.8 (1036)
Conclusions			

Visitor preferences: feeding sessions

Introduction	Differences in visiting	times during	feeding sessions:
Possible measures			
Data collection and analysis		Measured	95% confidence
➤Map of Apenheul	Area	difference	interval
≻Schematic map >Readers and areas	Squirrel monkey forest	20.3	(17.8, 22.9)
 ➤ Visitor preferences(1) 	Madagascar forest	22.5	(19.1, 26.0)
≻Visitor preferences(2)	Orang utan area	12.1	(7.3, 16.8)
≻Visitor preferences(3)	Gorilla island passage	18.2	(11.6, 24.9)
Scenarios and	Woolly monkey plaza	22.2	(16.2, 28.3)
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≻Ideal situation	S cc					
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≻Adjust feeding schedule (1)						
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≻Retain visitors						
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≻Combinations (2)						
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\geq Combinations (2)	
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1015 groups of visitors (4228 individual visitors)

Total capacity is 6000 visitors

Introduction	 1015 groups of visitors (4228 individual visitors)
Possible measures	
Data collection and analysis	■ Total capacity is 6000 visitors
Scenarios and models ≻Definitions	Maximal load in area = Capacity of area
 ➤Current situation >Ideal situation 	■ Ideal load in area — Capacity of area
 ≻Enlarge capacity ≻Adjust routing ≻Adjust feeding 	Total capacity
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≻Combinations (2)
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≻Results
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1015 groups of visitors (4228 individual visitors)

Total capacity is 6000 visitors

```
Maximal load in area = Capacity of area
```

```
■ Ideal load in area = \frac{\text{Capacity of area}}{\text{Total capacity}} \cdot \# \text{ visitors}
```

Effective load =
$$max(Load-Ideal load, 0)$$

• Overload = $\max(\text{Load-Capacity}, 0)$

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1015 groups of visitors (4228 individual visitors)

Total capacity is 6000 visitors

```
Maximal load in area = Capacity of area
```

```
■ Ideal load in area = \frac{\text{Capacity of area}}{\text{Total capacity}} \cdot \# \text{ visitors}
```

times

Effective load =
$$\max(\text{Load-Ideal load}, 0)$$

• Overload =
$$\max(\text{Load-Capacity}, 0)$$

Total effective load =
$$\sum_{areas} Effective load$$

areas times

Total overload
$$= \sum$$
 Overload

Current situation

Introduction	Visitors follow the routes as recorded
Possible measures	
Data collection and analysis	■ Total effective load: 54520
Scenarios and models ≻Definitions	■ Total overload: 4866
➤Current situation	
>Enlarge capacity	
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Two possible routes: the route in current order and in reversed order

Park chooses for each visitor which route he/she takes

Visitors decide on the time they spend in each area

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Two possible routes: the route in current order and in reversed order

Park chooses for each visitor which route he/she takes

Visitors decide on the time they spend in each area

Assignment of routes using a MILP model:

 \min Total effective load + Total overload \cdot Penalty costs

s.t. Each visitor gets a route

Load in area \leq Capacity + Overload

Load in area \leq Ideal load + Effective load

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Two possible routes: the route in current order and in reversed order

Park chooses for each visitor which route he/she takes

Visitors decide on the time they spend in each area

Assignment of routes using a MILP model:

 \min Total effective load + Total overload \cdot Penalty costs

s.t. Each visitor gets a route

Load in area \leq Capacity + Overload

Load in area \leq Ideal load + Effective load

Total effective load: 37910
 Total overload: 0

Enlarge capacity

Introduction	Add enough capaci ⁻
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Scenarios and models	Total overload:
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ty to eliminate all overload:

load: 50139 0

Enlarge capacity

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Add enough capacity to eliminate all overload:

Total effective load: 50139
 Total overload: 0

Add capacity to eliminate overload of three most overloaded areas (Dajak area, world's forest and crossroads baobab):

Total effective load: 52430
 Total overload: 2347

Adjust routing

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Two main routes: the current and the current in reversed order

Advise on which to take (changing over time; 90% follow advise):

Total effective load: 40227
 Total overload: 633

Adjust routing

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Two main routes: the current and the current in reversed order

Advise on which to take (changing over time; 90% follow advise):

Total effective load: 40227
 Total overload: 633

Free choice, but two routes clearly indicated:

Total effective load: 39394
 Total overload: 762

Adjust feeding schedule (1)

Introduction	Hourly feeding session:
Possible measures	
Data collection and analysis	◆ Total effective load: 44116
Scenarios and models	Total overload: 4123
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Hourly feeding session:

Total effective load: 44116
 Total overload: 4123

Hourly and two-hourly feeding sessions:

Total effective load: 44389 Total overload: 2483

Adjust feeding schedule (2)

Introduction	Two-hourly feeding session (simultaneously):
Possible measures	
Data collection and analysis	◆ Total effective load: 46803
Scenarios and models	Total overload: 2208
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Two-hourly feeding session (simultaneously):

```
    Total effective load: 46803
    Total overload: 2208
```

Two-hourly feeding session (spread):

• Total effective load: 47665

```
Total overload: 4679
```

Retain visitors in quiet areas

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Quiet areas: Madagascar forest, Orang utan area,
 Barbary macaque area and Children's playjungle

Extra feeding sessions in Orang utan area and Barbary macaque area:

Total effective load: 51406
 Total overload: 8388

Retain visitors in quiet areas

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Conclusions

Quiet areas: Madagascar forest, Orang utan area, Barbary macaque area and Children's playjungle

Extra feeding sessions in Orang utan area and Barbary macaque area:

Total effective load: 51406
 Total overload: 8388

Retain 80% of visitors 5 minutes longer in each of the four quiet areas:

Total effective load: 56105 Total overload: 3946

Introduction

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Scenarios and models

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 \succ Current situation

≻Ideal situation

≻Enlarge capacity

≻Adjust routing

≻Adjust feeding

schedule (1)

≻Adjust feeding

schedule (2)

≻Retain visitors

≻Combinations (1)

≻Combinations (2)

≻Results

Conclusions

One could also combine different measures

Capacity: expand partly

Routing: two main routes without advise

Feeding: presentation every one and two hours

Retain visitors: with help of new attractions (80% will stay 5 minutes longer)

Introduction		Total	Total
Possible measures	Combination	effective load	overload
Data collection and analysis	Capacity & routing	36898	130
Scenarios and models	Capacity & feeding	41865	602
≻Definitions	Capacity & retain	54632	1698
Current situationIdeal situation	Routing & feeding	39431	7988
Enlarge capacityAdjust routing	Routing & retain	37621	409
>Adjust feeding schedule (1)	Feeding & retain	41977	2434
>Adjust feeding schedule (2)	Capacity, routing & feeding	36585	5137
≻Retain visitors	Capacity, routing & retain	35404	148
➤Combinations (1) ➤Combinations (2)	Capacity, feeding & retain	39662	445
≻Results	Routing, feeding & retain	37834	8095
Conclusions	All measures	35139	5564

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Summary of results

Introduction		Total	Total
Possible measures		effective load	overload
Data collection and analysis	Current situation	54520	4866
Scenarios and models	Ideal situation	37910	0
≻Definitions	Capacity	52430	2347
➤Current situation>Ideal situation	Routing	39394	762
≻Enlarge capacity	Feeding	44389	2483
 Adjust routing Adjust feeding schedule (1) 	Retain	56105	4679
≻Adjust feeding schedule (2)	Capacity & routing	36898	130
≻Retain visitors	Routing & retain	37621	409
≻Combinations (1)≻Combinations (2)	Capacity, routing & retain	35404	148
≻Results Conclusions	All measures	35139	5564

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≻Conclusions

Visitors follow the indicated route

■ Visitors spend time at feeding sessions

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➤Conclusions

Visitors follow the indicated route

Visitors spend time at feeding sessions

More equal spreading of visitors can be obtained by using two main routes

Possibly combine with adding capacity and/or retaining visitors in quiet areas

Also changing the feeding sessions schedule will not help

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Master's thesis (in Dutch) can be found at: http://arno.uvt.nl/show.cgi?fid=82078

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Questions?

Thank you for your attention!

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