

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

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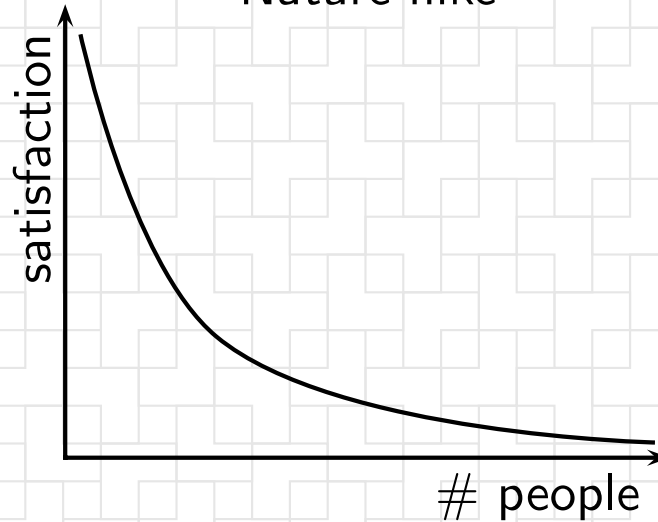
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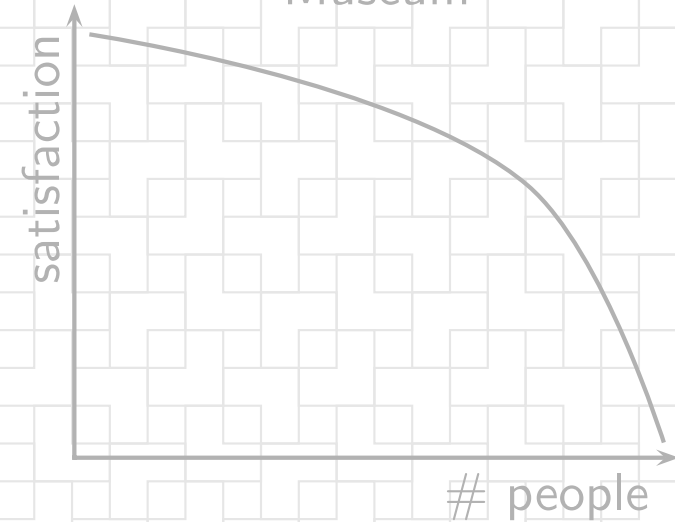
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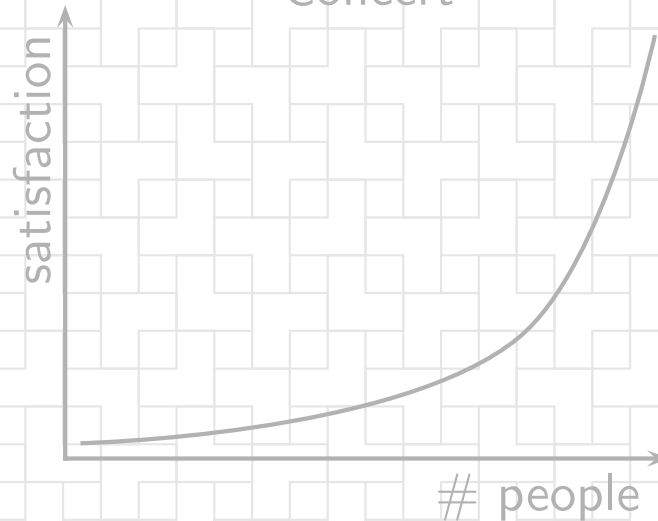
Nature hike



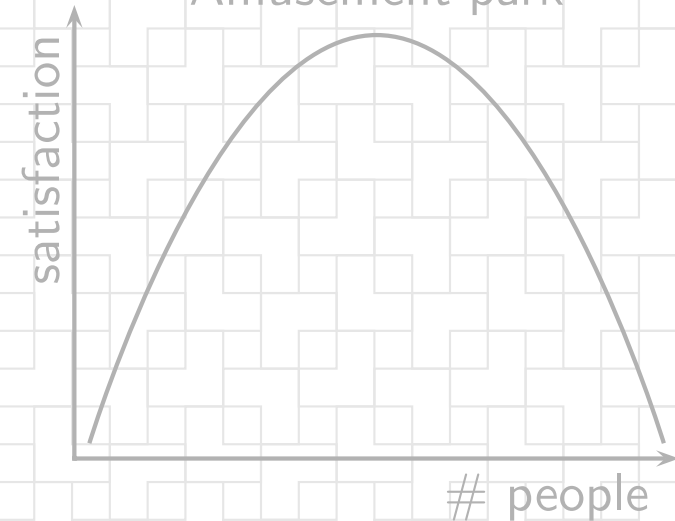
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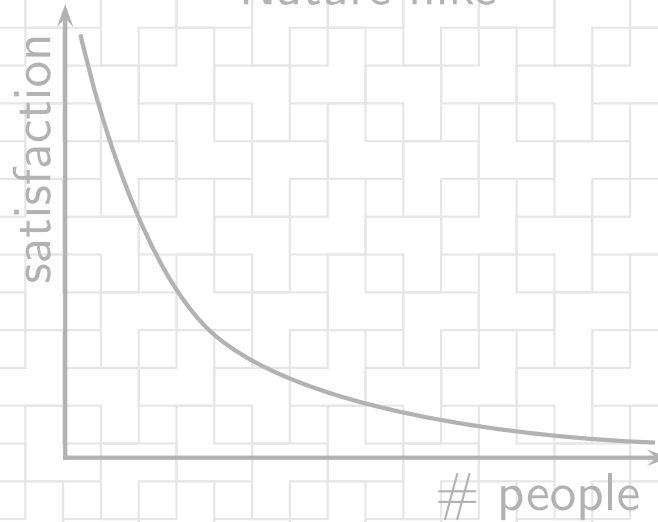
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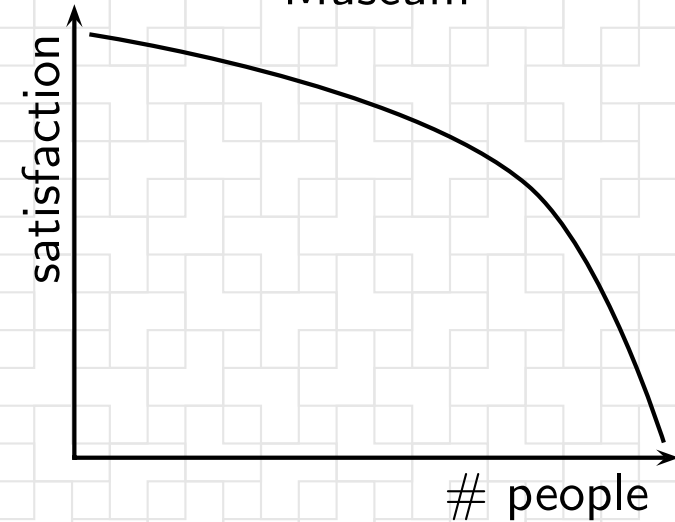
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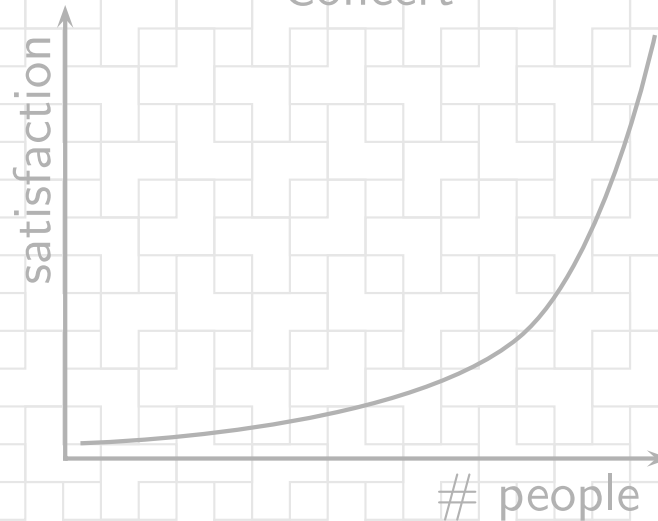
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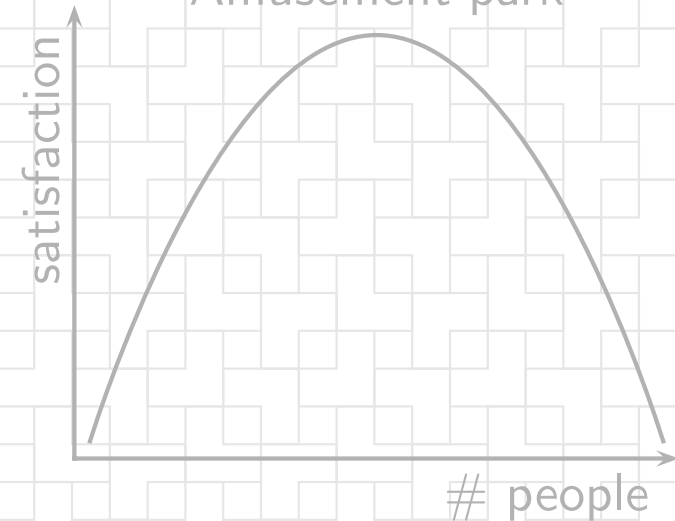
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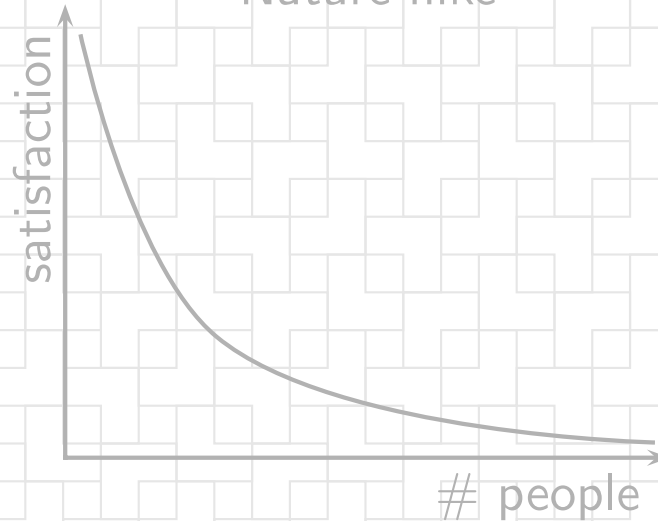
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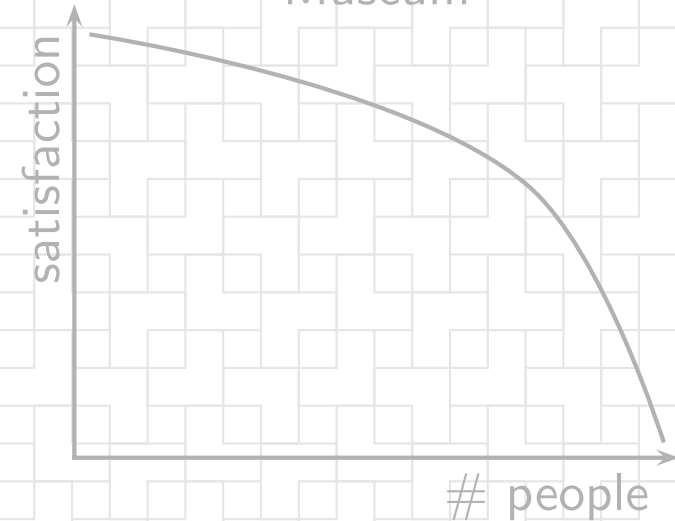
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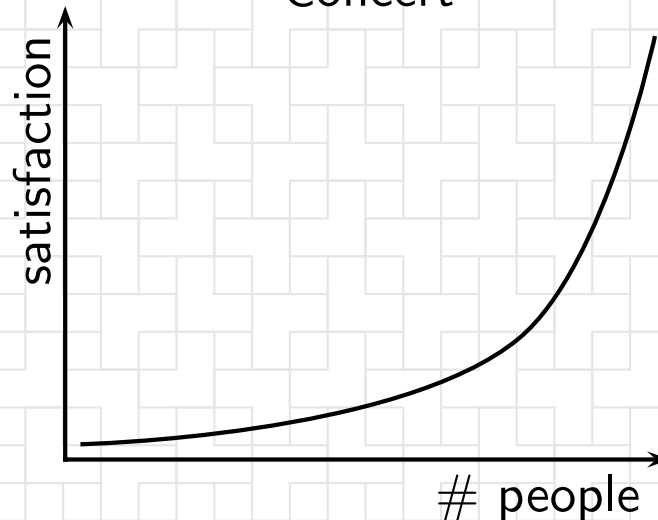
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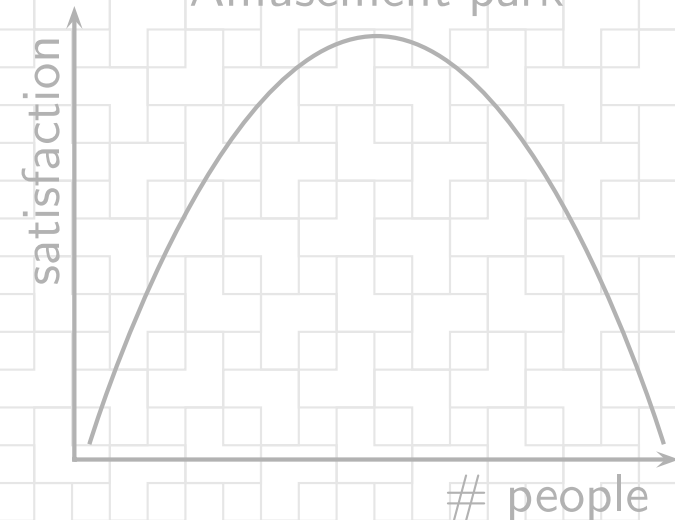
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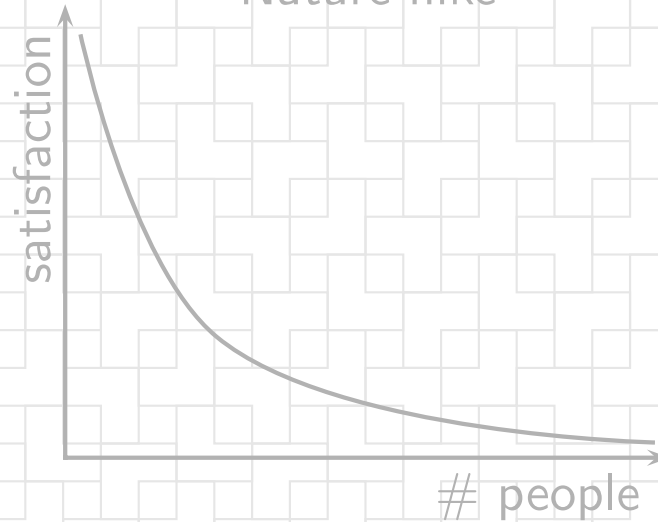
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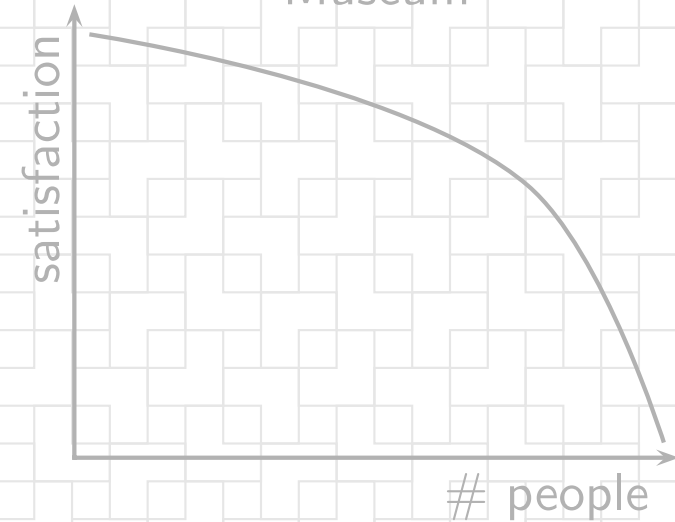
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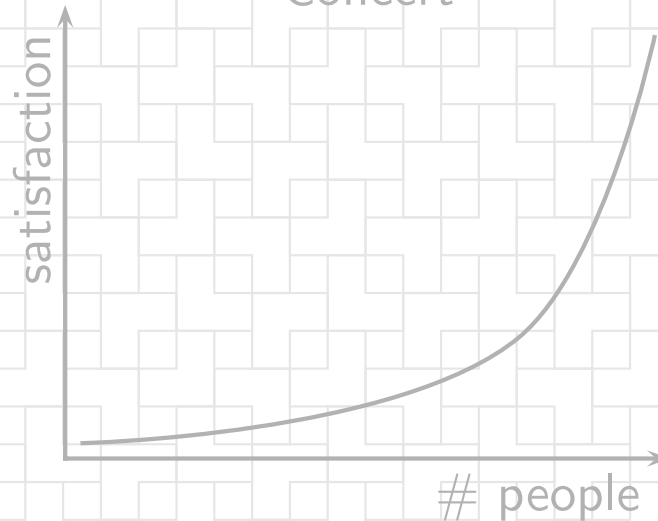
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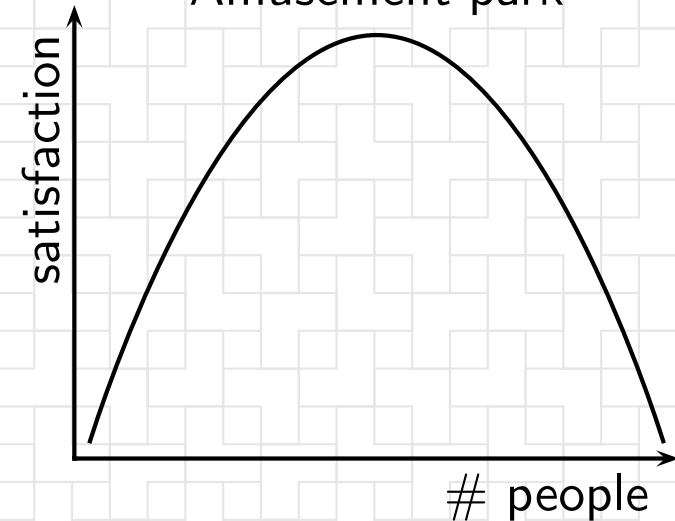
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- Zoo with primarily monkeys and apes
- Some monkeys walk around freely
- Other monkeys live on islands

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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

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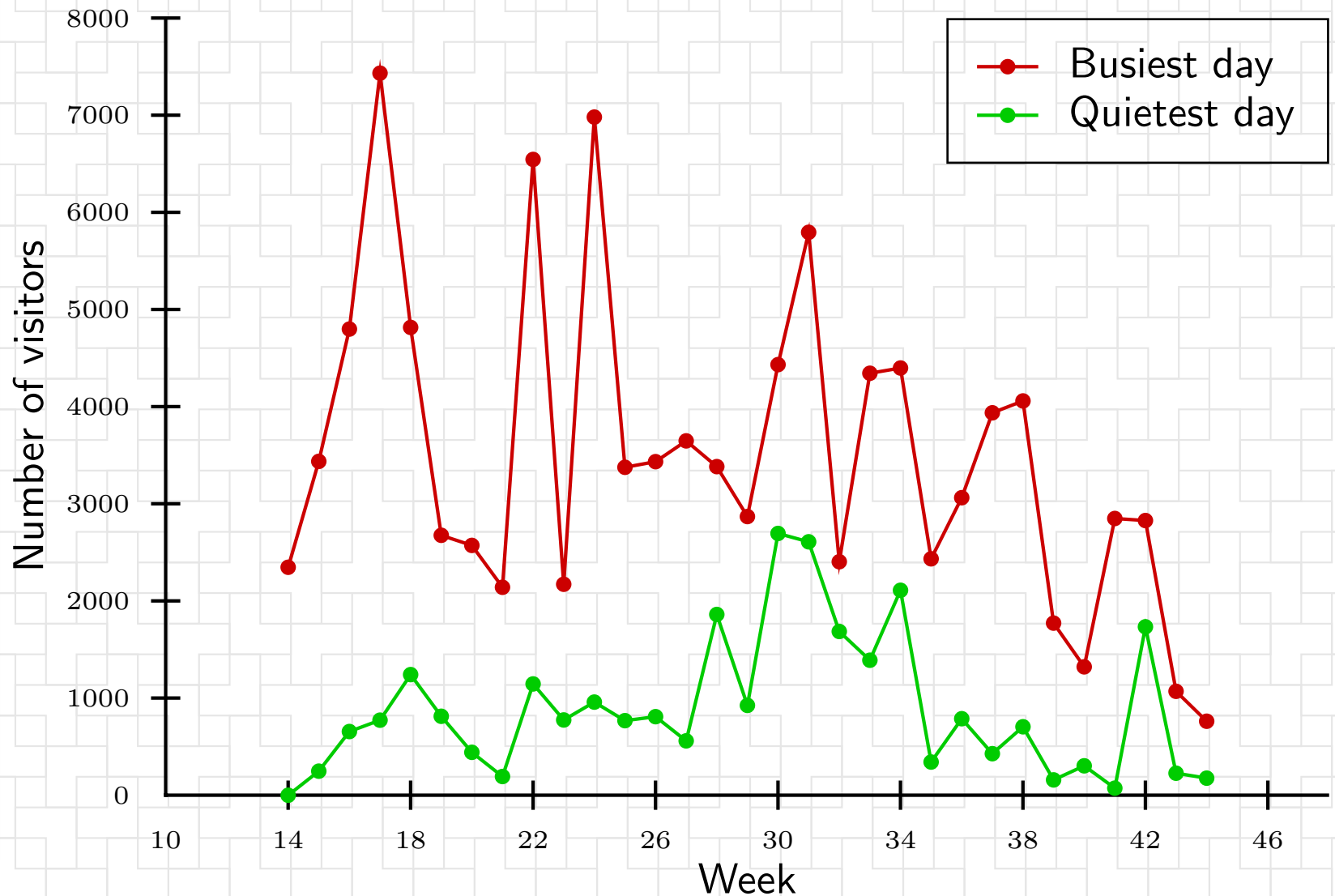
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Apenheul: busy & quiet days

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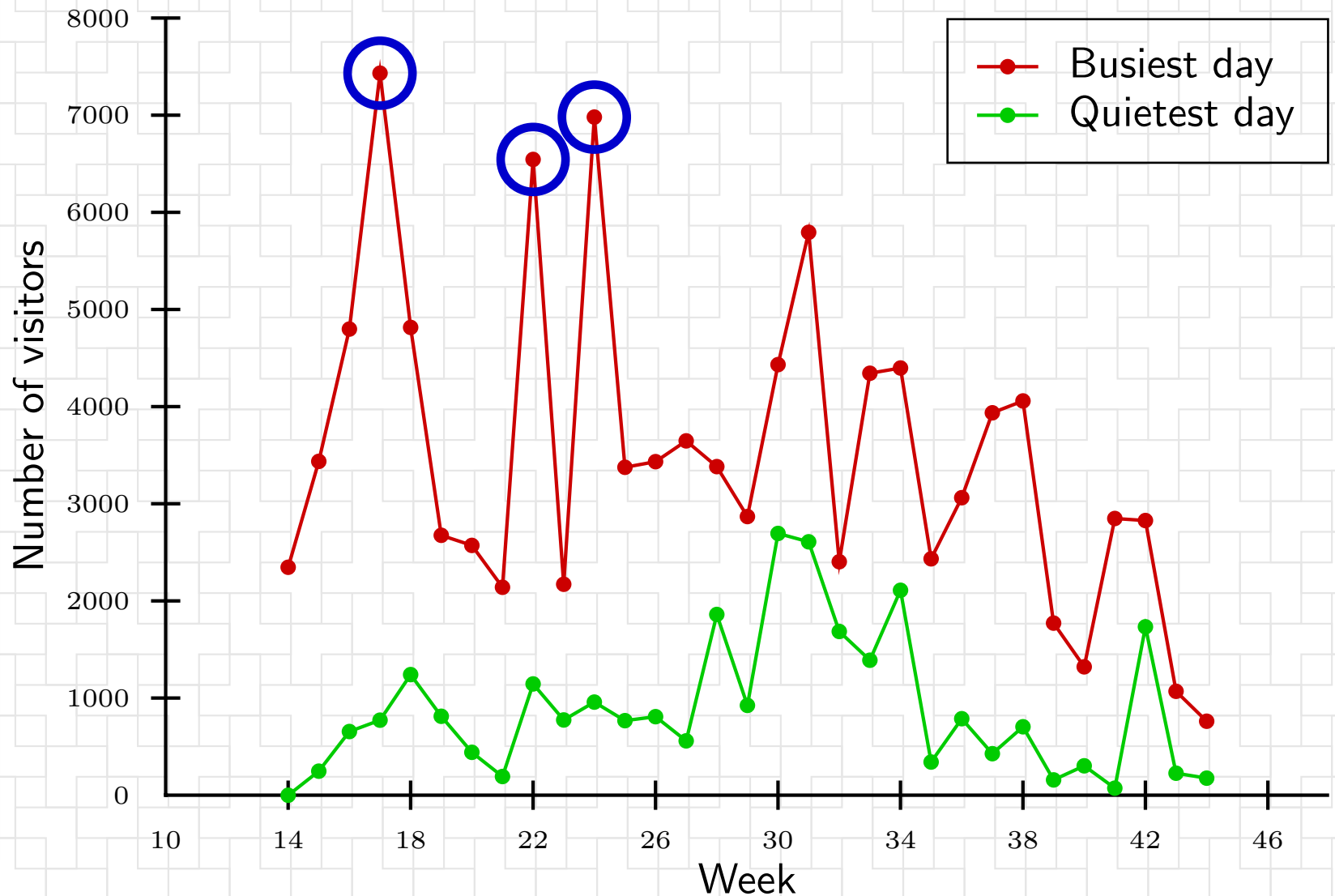
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Problem & causes

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- Problem: on busy days it can be very busy in some areas, while other areas are still relatively quiet.
- Causes:
 - ◆ Feeding sessions
 - ◆ Some areas are more appealing than others:
 - Areas with monkeys walking around freely
 - Lookouts
 - Areas with less animals

Squirrel monkeys (1)



Squirrel monkeys (2)



Spider monkeys



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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

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Conclusions

- 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

⇒ Visitors are displeased

Research question

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- Improve the physical flow of visitors such that:
 - ◆ The relatively busy areas become quieter
 - ◆ The relatively quiet areas become busier

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- (Im)possibilities
- Measures (1)
- 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

(Im)possibilities

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➤ Measures (1)

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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)

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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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➤ Measures (2)

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■ Expand capacity

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

■ Routing

- ◆ Two routes with advise on which to take
- ◆ Two routes without advise on which to take

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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■ 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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- 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

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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

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➤ **Map of Apenheul**

➤ Schematic map

➤ Readers and areas

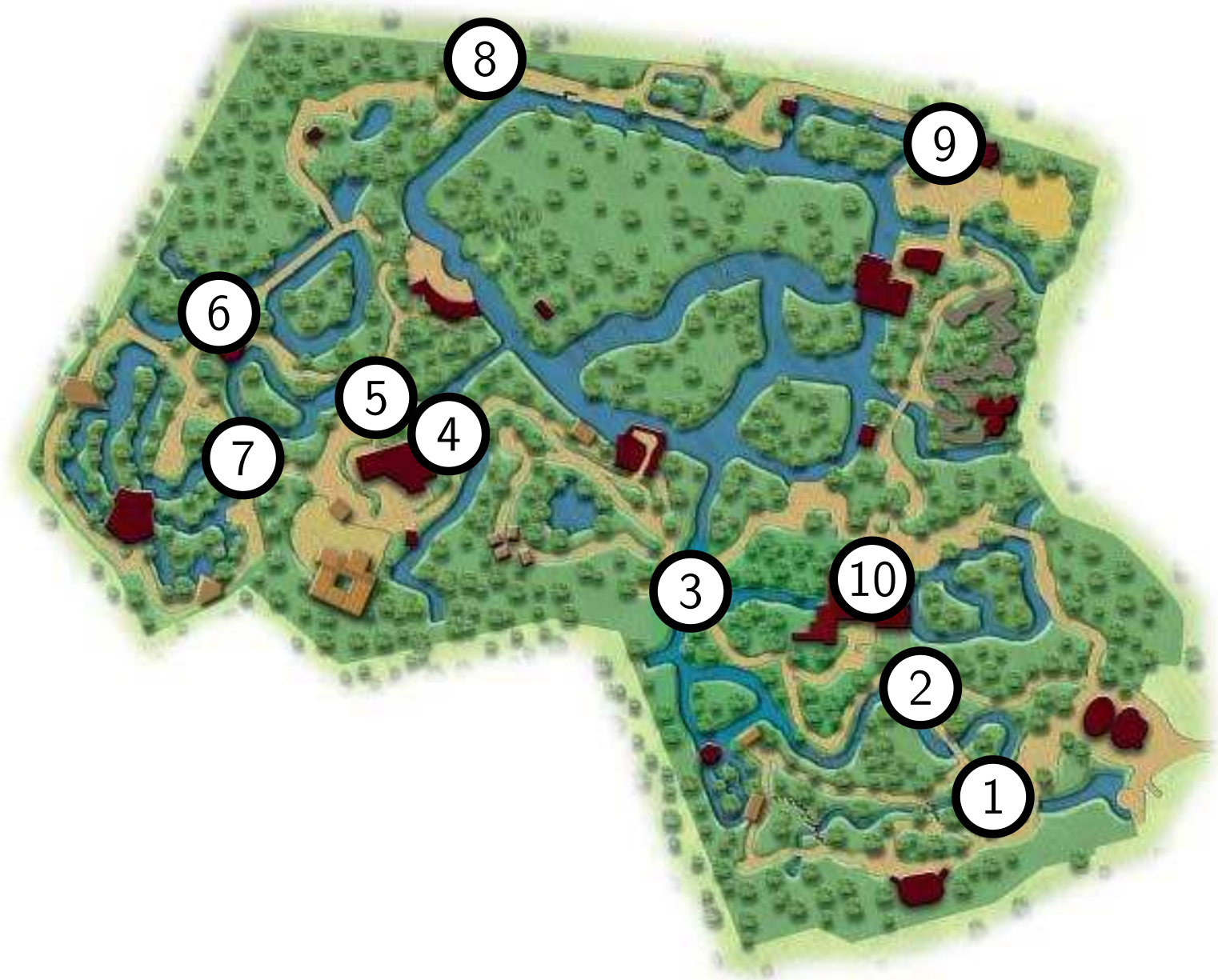
➤ Visitor preferences(1)

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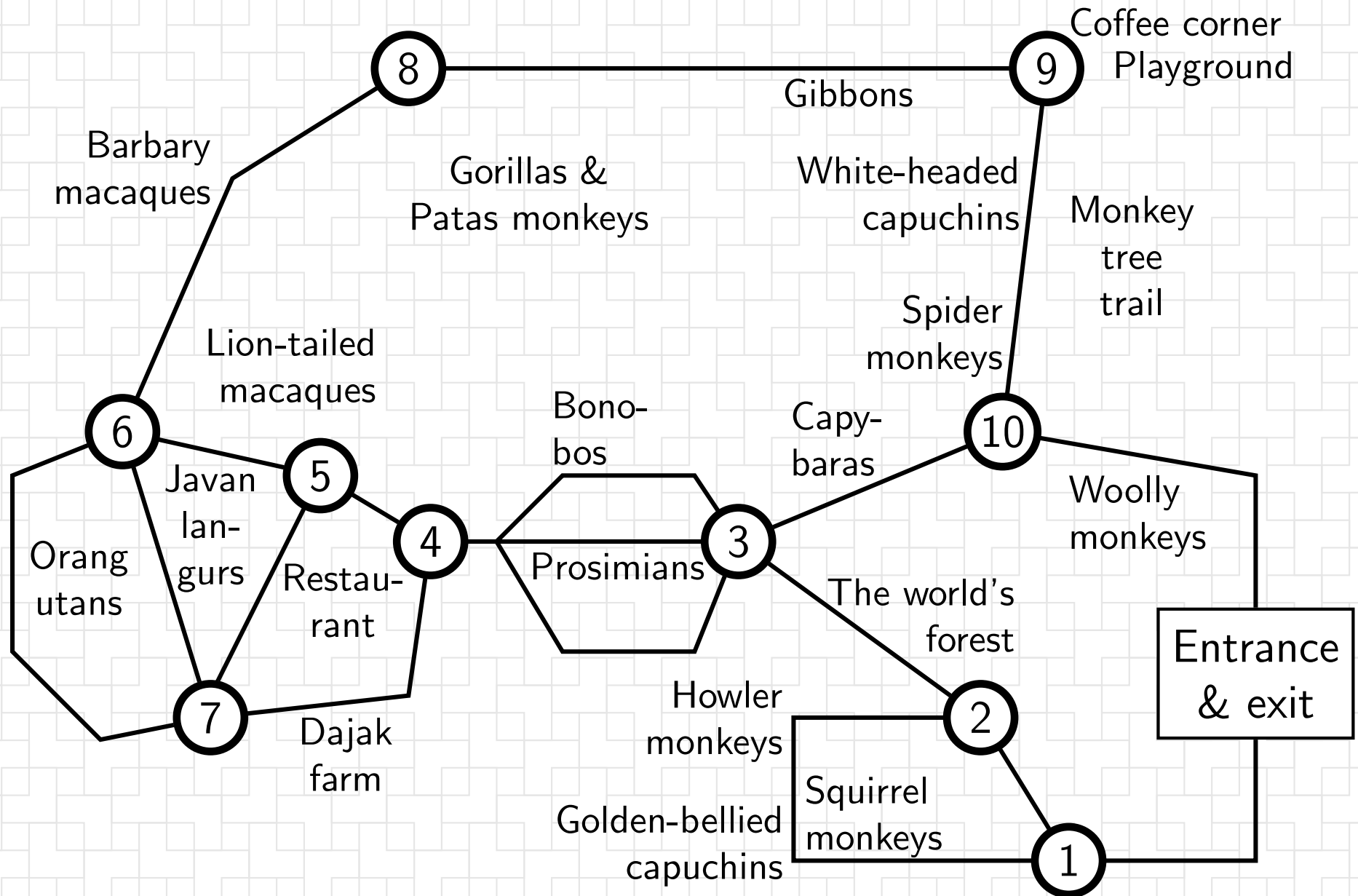
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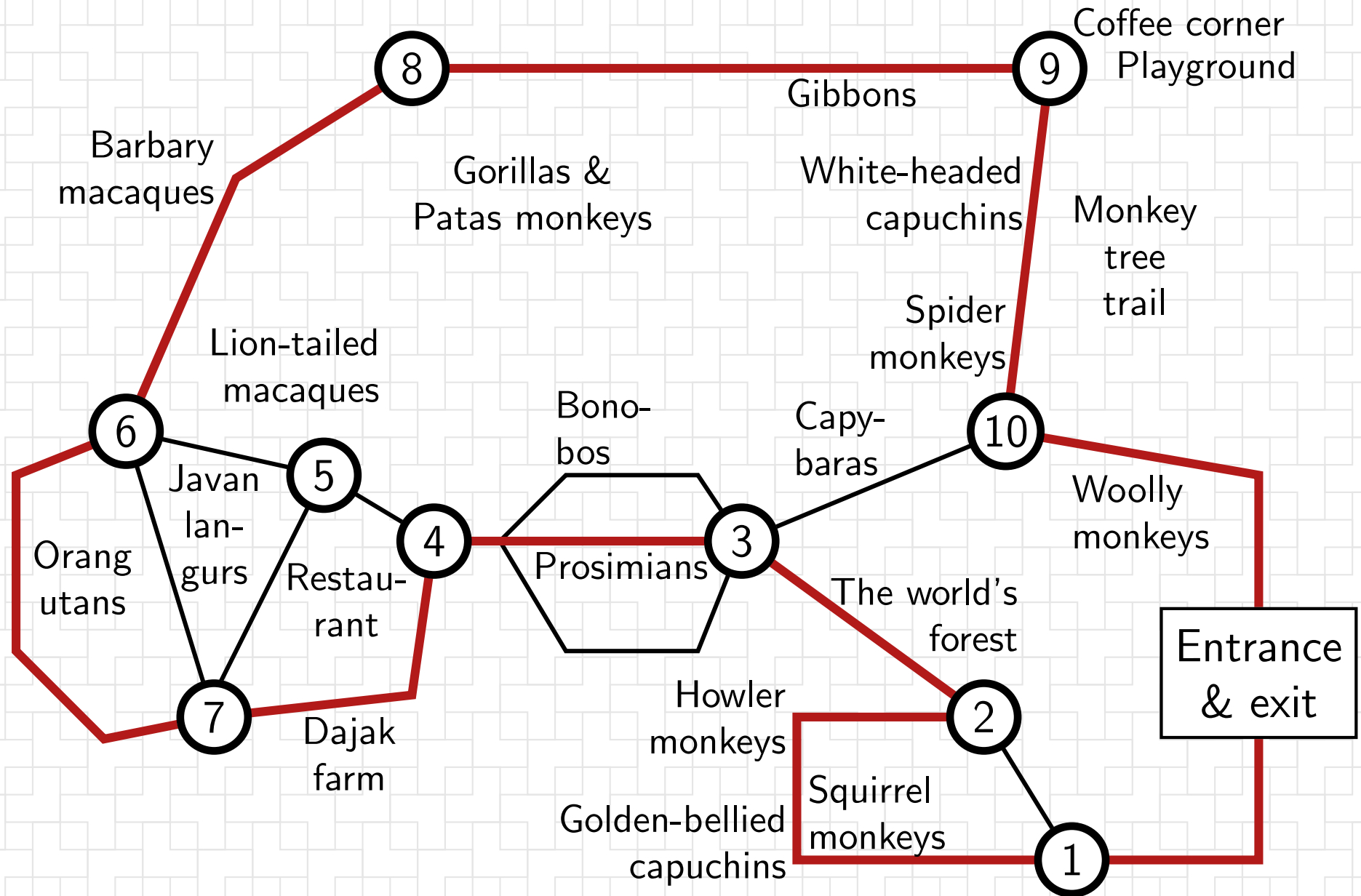
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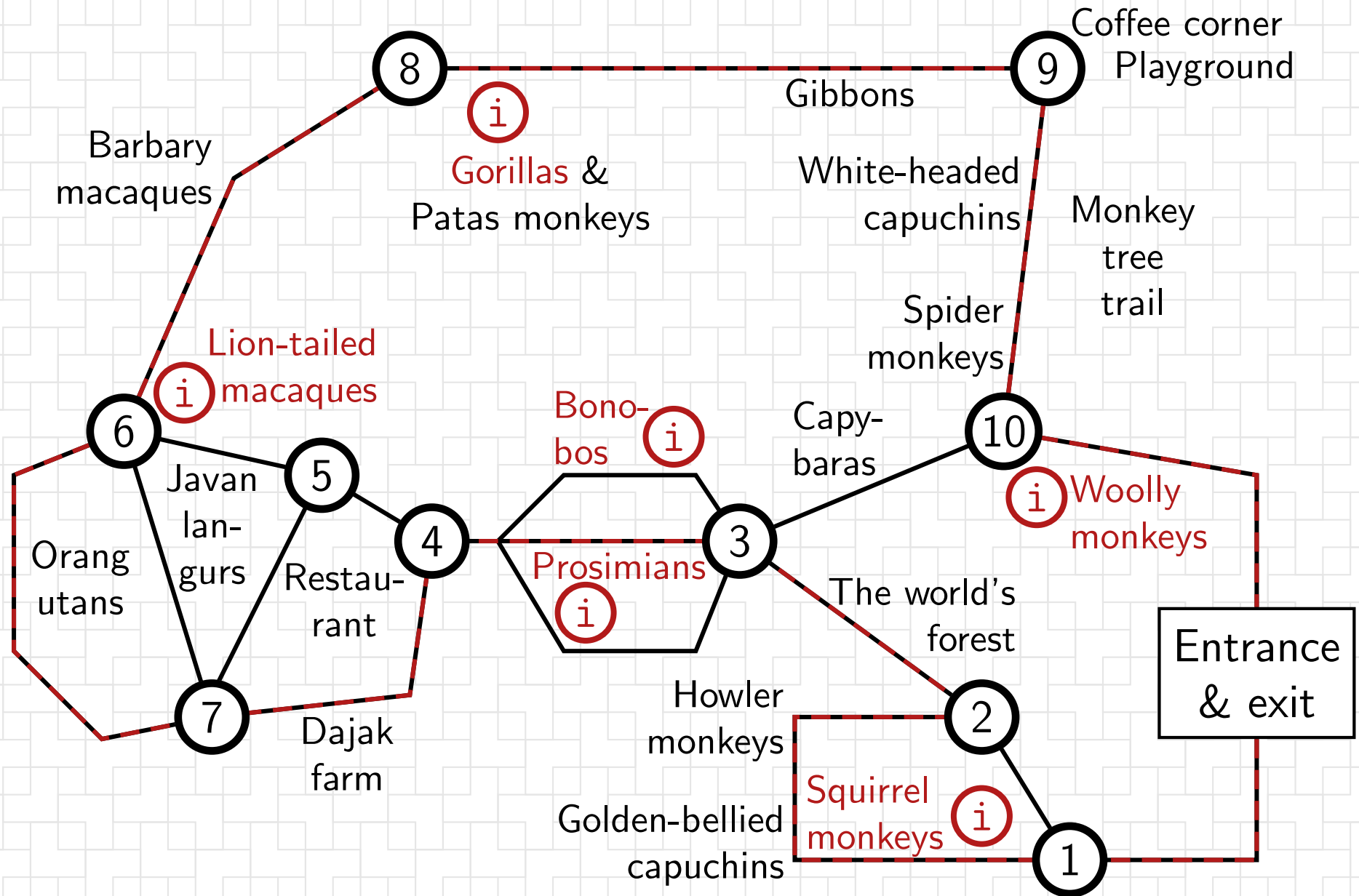
Schematic map of Apenheul



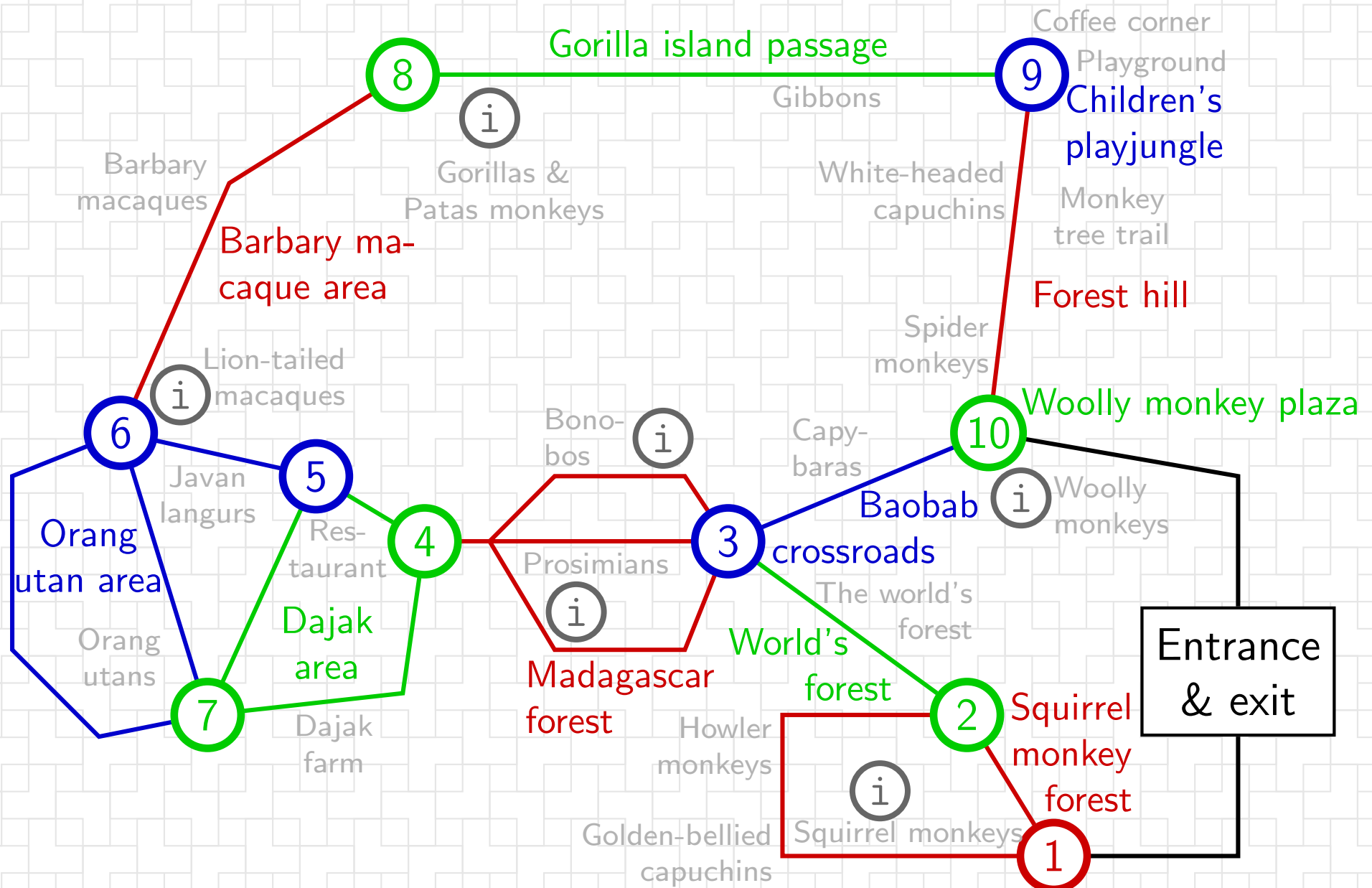
Schematic map of Apenheul



Schematic map of Apenheul



Readers and areas



Visitor preferences: visitor routes

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- 1015 unique (groups of) visitors
- 326 different routes
- The majority follows the indicated route

Visitor preferences: visiting times

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Area	Average	Standard deviation	Number of visits
Squirrel monkey forest	15.5	11.96	1618
World's forest	6.0	6.19	2440
Crossroads baobab	5.6	10.12	1790
Madagascar forest	9.8	9.97	1274
Dajak area	39.5	21.25	1189
Orang utan area	13.9	9.10	1088
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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Visitor preferences: feeding sessions

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- **Visitor preferences(3)**

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■ Visiting times during/outside feeding sessions:

Area	During feeding (# visits)	Outside feeding (# visits)
Squirrel monkey forest	31.4 (203)	11.0 (818)
Madagascar forest	29.6 (80)	7.0 (824)
Orang utan area	24.9 (45)	12.9 (889)
Gorilla island passage	31.7 (38)	13.4 (809)
Woolly monkey plaza	32.1 (43)	9.8 (1036)

Visitor preferences: feeding sessions

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■ Differences in visiting times during feeding sessions:

Area	Measured difference	95% confidence interval
Squirrel monkey forest	20.3	(17.8, 22.9)
Madagascar forest	22.5	(19.1, 26.0)
Orang utan area	12.1	(7.3, 16.8)
Gorilla island passage	18.2	(11.6, 24.9)
Woolly monkey plaza	22.2	(16.2, 28.3)

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- 1015 groups of visitors (4228 individual visitors)
- Total capacity is 6000 visitors

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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 = $\frac{\text{Capacity of area}}{\text{Total capacity}} \cdot \# \text{ visitors}$

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

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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 = $\frac{\text{Capacity of area}}{\text{Total capacity}} \cdot \# \text{ visitors}$

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

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

■ Total effective load = $\sum_{\substack{\text{areas} \\ \text{times}}} \text{Effective load}$

■ Total overload = $\sum_{\substack{\text{areas} \\ \text{times}}} \text{Overload}$

Current situation

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- Visitors follow the routes as recorded
- Total effective load: 54520
- Total overload: 4866

Ideal situation

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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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Conclusions

- 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 · Penalty costs
 - s.t. Each visitor gets a route
 - Load in area $\leq$ Capacity + Overload
 - Load in area $\leq$ Ideal load + Effective load

Ideal situation

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Conclusions

- 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:
$$\begin{array}{ll} \min & \text{Total effective load} + \text{Total overload} \cdot \text{Penalty costs} \\ \text{s.t.} & \text{Each visitor gets a route} \\ & \text{Load in area} \leq \text{Capacity} + \text{Overload} \\ & \text{Load in area} \leq \text{Ideal load} + \text{Effective load} \end{array}$$
- Total effective load: 37910
Total overload: 0

Enlarge capacity

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- Add enough capacity to eliminate all overload:
 - ◆ Total effective load: 50139
 - Total overload: 0

Enlarge capacity

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Conclusions

- 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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Conclusions

- 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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Conclusions

- 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)

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■ Hourly feeding session:

- ◆ Total effective load: 44116
- Total overload: 4123

Adjust feeding schedule (1)

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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)

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■ Two-hourly feeding session (simultaneously):

- ◆ Total effective load: 46803
- Total overload: 2208

Adjust feeding schedule (2)

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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

Combinations (1)

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- 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)

Combinations (2)

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Combination	Total effective load	Total overload
Capacity & routing	36898	130
Capacity & feeding	41865	602
Capacity & retain	54632	1698
Routing & feeding	39431	7988
Routing & retain	37621	409
Feeding & retain	41977	2434
Capacity, routing & feeding	36585	5137
Capacity, routing & retain	35404	148
Capacity, feeding & retain	39662	445
Routing, feeding & retain	37834	8095
All measures	35139	5564

Combinations (2)

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Combinations (2)

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Combinations (2)

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	Total effective load	Total overload
Current situation	54520	4866
Ideal situation	37910	0
-----	-----	-----
Capacity	52430	2347
Routing	39394	762
Feeding	44389	2483
Retain	56105	4679
-----	-----	-----
Capacity & routing	36898	130
Routing & retain	37621	409
Capacity, routing & retain	35404	148
All measures	35139	5564

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- 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

Conclusions

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

Questions?



Thank you for your attention!