Analyzing Clickstreams Using Subsessions

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Presented by Nicholas Tinggaard

Outline

- Motivation / The Case
- What is Clickstreams
- Existing models
- New combined solution
- Problems / solutions
- Evaluation
- Conclusion
- Relation to our work

Motivation / The Case

- Corporate web
  - Personalisation
  - Optimisation
  - Adaptive sites
- Analysing user behaviour
  - Sequences of clicks
  - SpeedTracer from IBM
    - No Data Warehouse
      - □ Inflexible
      - □ No OLAP
- Nykredit case (Danish mortage provider)
  - Banner effiency
  - Session kills (killer subsessions)
    - Parts of the website that could be badly written or structured

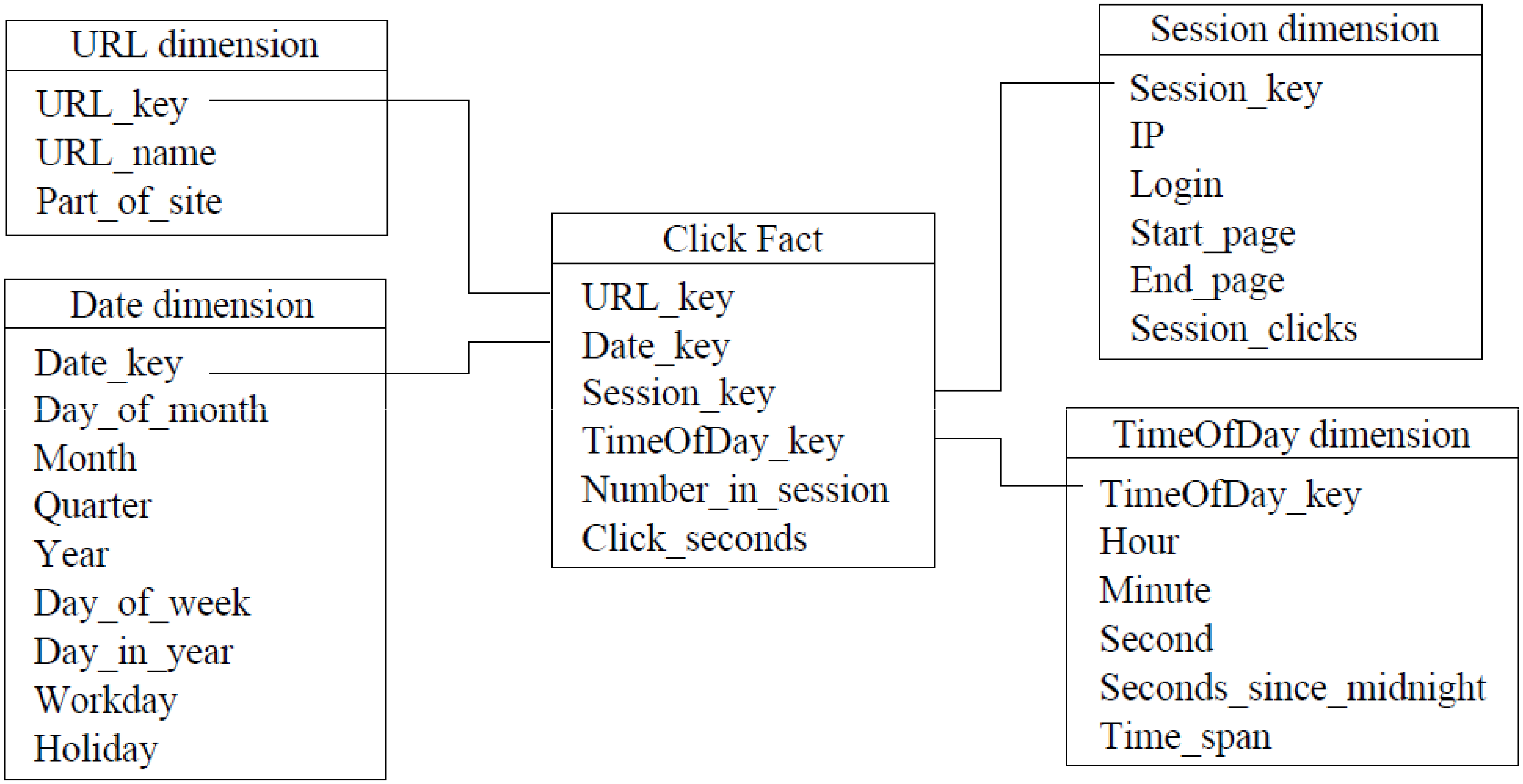
What is Clickstreams

- Sequences of clicks on a website
- User session
- Web server log file
  - IP Address, URL, Timestamp
    - Time on each page, Group users on different terms like geography
  - Cookie
- Existing modelling methods
  - Click Fact Table
  - Session Fact Table
  - Existing methods has limitations
- New Subsession model

Click Fact Table

- Click fact introduced by R. Kimball
- Star-Schema
  - Single clicks as facts
  - Good detail level
  - Hard to query sequences of clicks
    - Multiple self-joins on the fact table
  - Designed for queries on single clicks

Click Fact Star Schema



URL dimension
- URL_key
- URL_name
- Part_of_site

Date dimension
- Date_key
- Day_of_month
- Month
- Quarter
- Year
- Day_of_week
- Day_in_year
- Workday
- Holiday

Click Fact
- URL_key
- Date_key
- Session_key
- TimeOfDay_key
- Number_in_session
- Click_seconds

Session dimension
- Session_key
- IP
- Login
- Start_page
- End_page
- Session_clicks

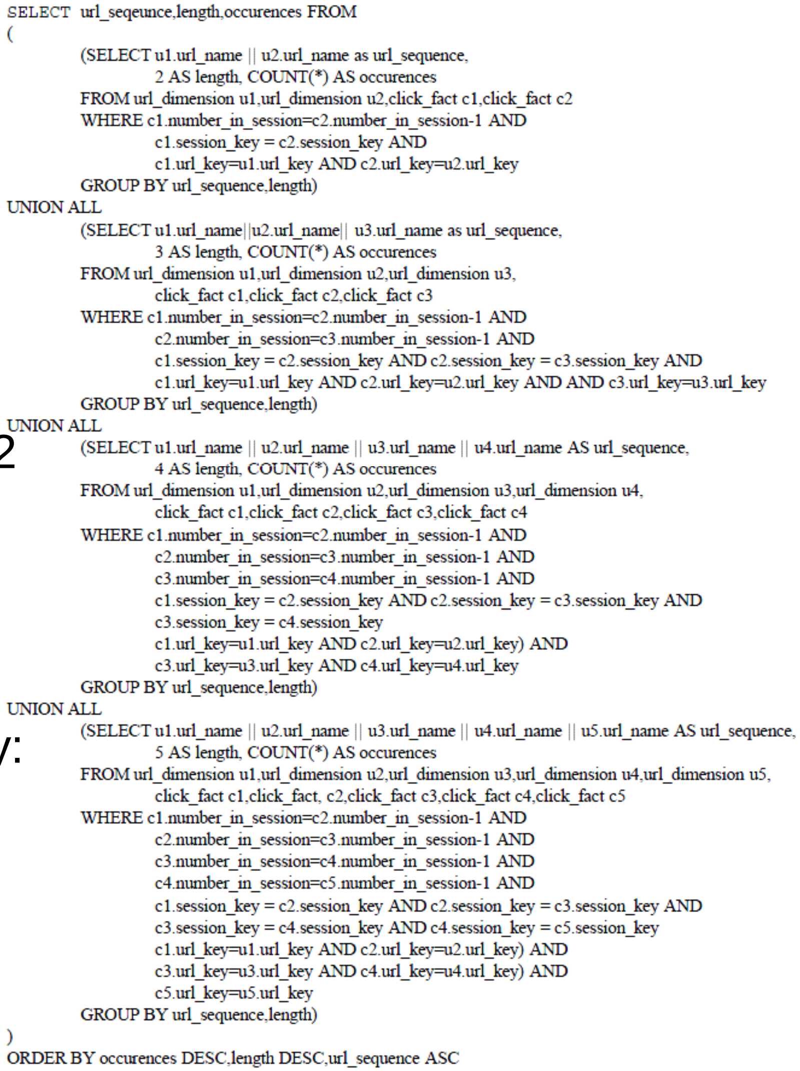
TimeOfDay dimension
- TimeOfDay_key
- Hour
- Minute
- Second
- Seconds_since_midnight
- Time_span

Figure 8: Click Fact Star Schema

Simple sequence query on a Click fact model

- Simple query that selects sequences of clicks up to 5 in length
- Arrange the results after longest and most frequent occurring sequences

- The query in short words:
  - Selects all sequences of length 2
  - Union all sequences of length 3
  - Union all sequences of length 4
  - Union all sequences of length 5
  - On the constructed set the query:
  - Group by occurrences, length and url_sequence

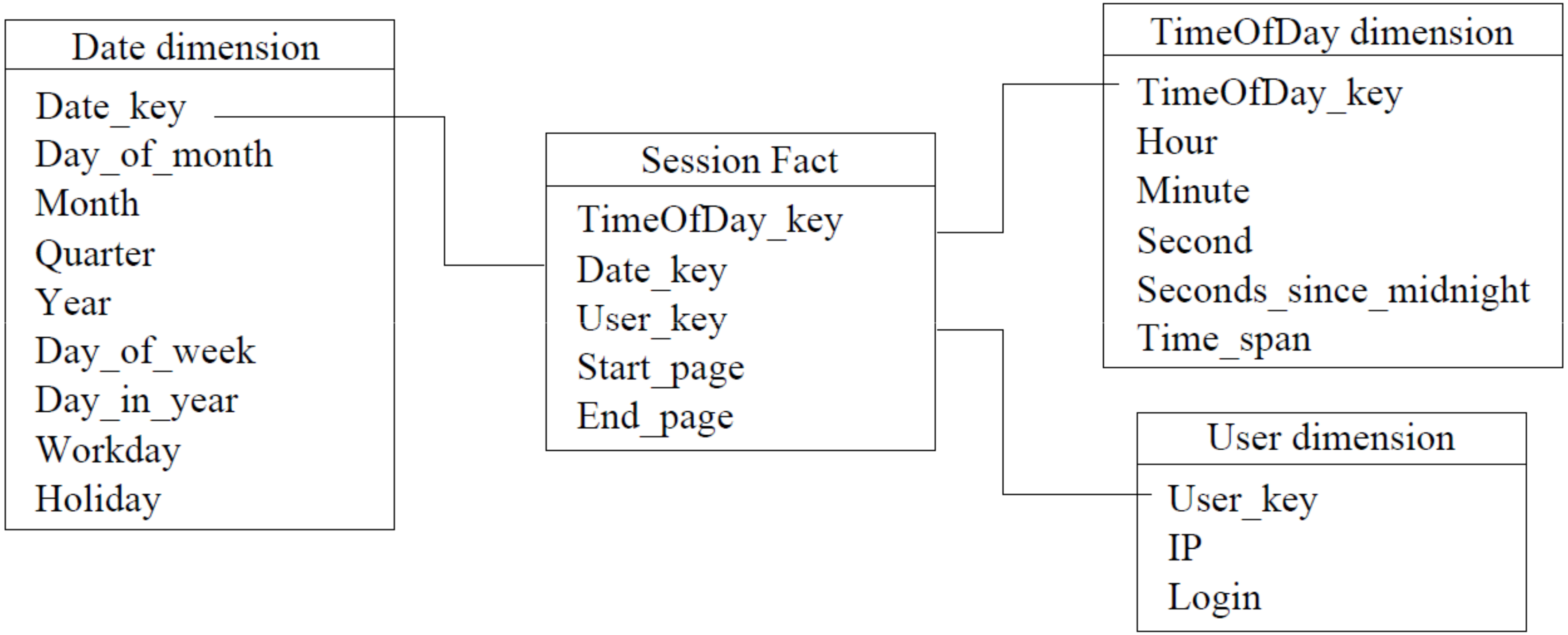


```
SELECT  url_seqeunce,length,occurences FROM
(
        (SELECT u1.url_name || u2.url_name as url_sequence,
                2 AS length, COUNT(*) AS occurences
        FROM url_dimension u1,url_dimension u2,click_fact c1,click_fact c2
        WHERE c1.number_in_session=c2.number_in_session-1 AND
                c1.session_key = c2.session_key AND
                c1.url_key=u1.url_key AND c2.url_key=u2.url_key
        GROUP BY url_sequence,length)
UNION ALL
        (SELECT u1.url_name||u2.url_name|| u3.url_name as url_sequence,
                3 AS length, COUNT(*) AS occurences
        FROM url_dimension u1,url_dimension u2,url_dimension u3,
                click_fact c1,click_fact c2,click_fact c3
        WHERE c1.number_in_session=c2.number_in_session-1 AND
                c2.number_in_session=c3.number_in_session-1 AND
                c1.session_key = c2.session_key AND c2.session_key = c3.session_key AND
                c1.url_key=u1.url_key AND c2.url_key=u2.url_key AND AND c3.url_key=u3.url_key
        GROUP BY url_sequence,length)
UNION ALL
        (SELECT u1.url_name || u2.url_name || u3.url_name || u4.url_name AS url_sequence,
                4 AS length, COUNT(*) AS occurences
        FROM url_dimension u1,url_dimension u2,url_dimension u3,url_dimension u4,
                click_fact c1,click_fact c2,click_fact c3,click_fact c4
        WHERE c1.number_in_session=c2.number_in_session-1 AND
                c2.number_in_session=c3.number_in_session-1 AND
                c3.number_in_session=c4.number_in_session-1 AND
                c1.session_key = c2.session_key AND c2.session_key = c3.session_key AND
                c3.session_key = c4.session_key
                c1.url_key=u1.url_key AND c2.url_key=u2.url_key) AND
                c3.url_key=u3.url_key AND c4.url_key=u4.url_key
        GROUP BY url_sequence,length)
UNION ALL
        (SELECT u1.url_name || u2.url_name || u3.url_name || u4.url_name || u5.url_name AS url_sequence,
                5 AS length, COUNT(*) AS occurences
        FROM url_dimension u1,url_dimension u2,url_dimension u3,url_dimension u4,url_dimension u5,
                click_fact c1,click_fact, c2,click_fact c3,click_fact c4,click_fact c5
        WHERE c1.number_in_session=c2.number_in_session-1 AND
                c2.number_in_session=c3.number_in_session-1 AND
                c3.number_in_session=c4.number_in_session-1 AND
                c4.number_in_session=c5.number_in_session-1 AND
                c1.session_key = c2.session_key AND c2.session_key = c3.session_key AND
                c3.session_key = c4.session_key AND c4.session_key = c5.session_key
                c1.url_key=u1.url_key AND c2.url_key=u2.url_key) AND
                c3.url_key=u3.url_key AND c4.url_key=u4.url_key) AND
                c5.url_key=u5.url_key
        GROUP BY url_sequence,length)
)
ORDER BY occurences DESC,length DESC,url_sequence ASC
```

Session Fact Table

- Star-Schema
  - Sessions as facts
  - Session questions is easy to query
    - Queries that is about start and end page
  - Internal clicks gets lost
    - Not useful for behaviour analysis

Session Fact Schema



Date dimension

Date_key
Day_of_month
Month
Quarter
Year
Day_of_week
Day_in_year
Workday
Holiday

Session Fact

TimeOfDay_key
Date_key
User_key
Start_page
End_page

TimeOfDay dimension

TimeOfDay_key
Hour
Minute
Second
Seconds_since_midnight
Time_span

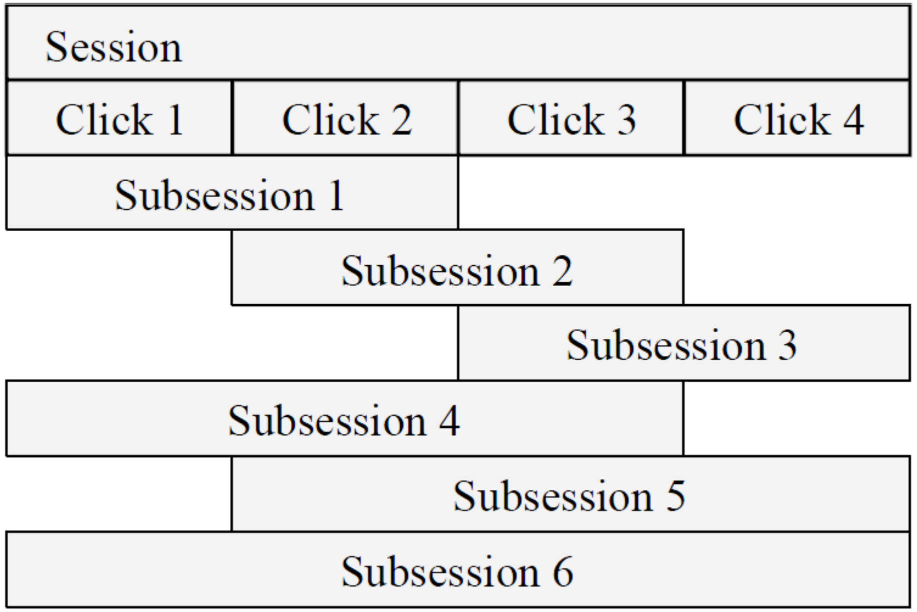
User dimension

User_key
IP
Login

Figure 9: Session fact star scheme

Subsession fact model

- Store all possible sequences of clicks from each session
  - Sessions span many subsession
  - Subsessions overlap
- URL sequence dimension
  - Stores summarised fact ir



Session

Click 1

Click 2

Click 3

Click 4

Subsession 1

Subsession 2

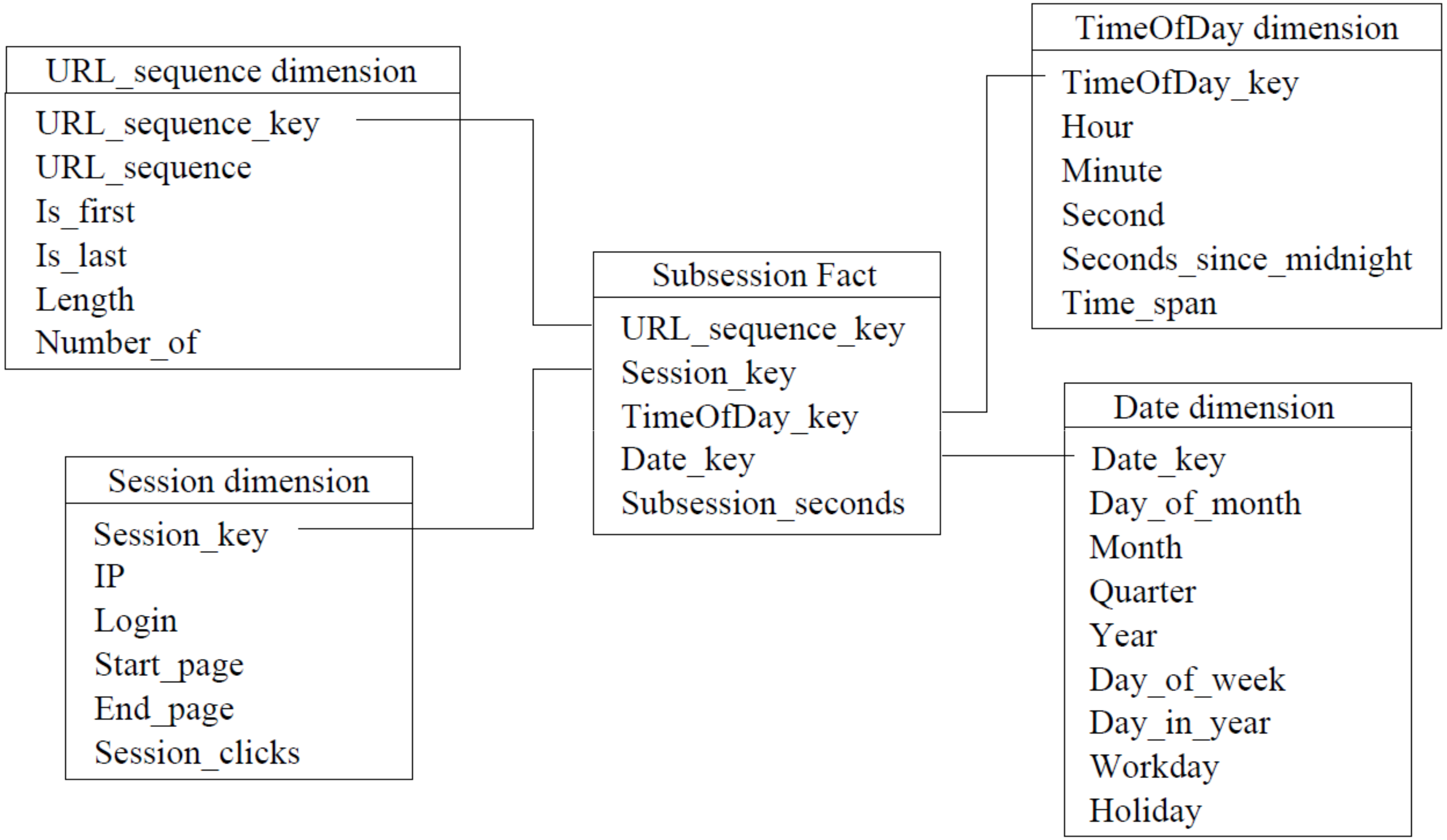
Subsession 3

Subsession 4

Subsession 5

Subsession 6

Subsession Fact Star Schema



URL_sequence dimension

URL_sequence_key
URL_sequence
Is_first
Is_last
Length
Number_of

Session dimension

Session_key
IP
Login
Start_page
End_page
Session_clicks

Subsession Fact

URL_sequence_key
Session_key
TimeOfDay_key
Date_key
Subsession_seconds

TimeOfDay dimension

TimeOfDay_key
Hour
Minute
Second
Seconds_since_midnight
Time_span

Date dimension

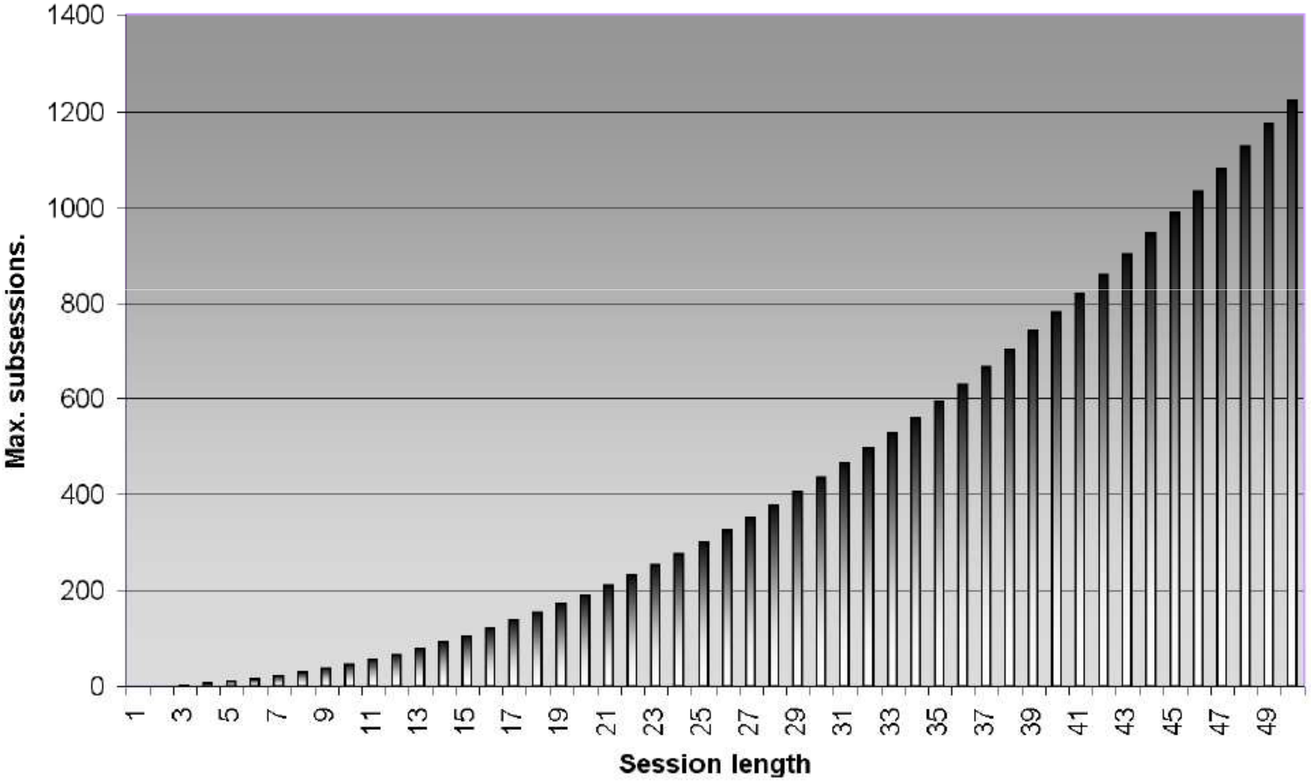
Date_key
Day_of_month
Month
Quarter
Year
Day_of_week
Day_in_year
Workday
Holiday

Figure 2: Subsession Star Schema

Subsession counts

sl = Length of sequence

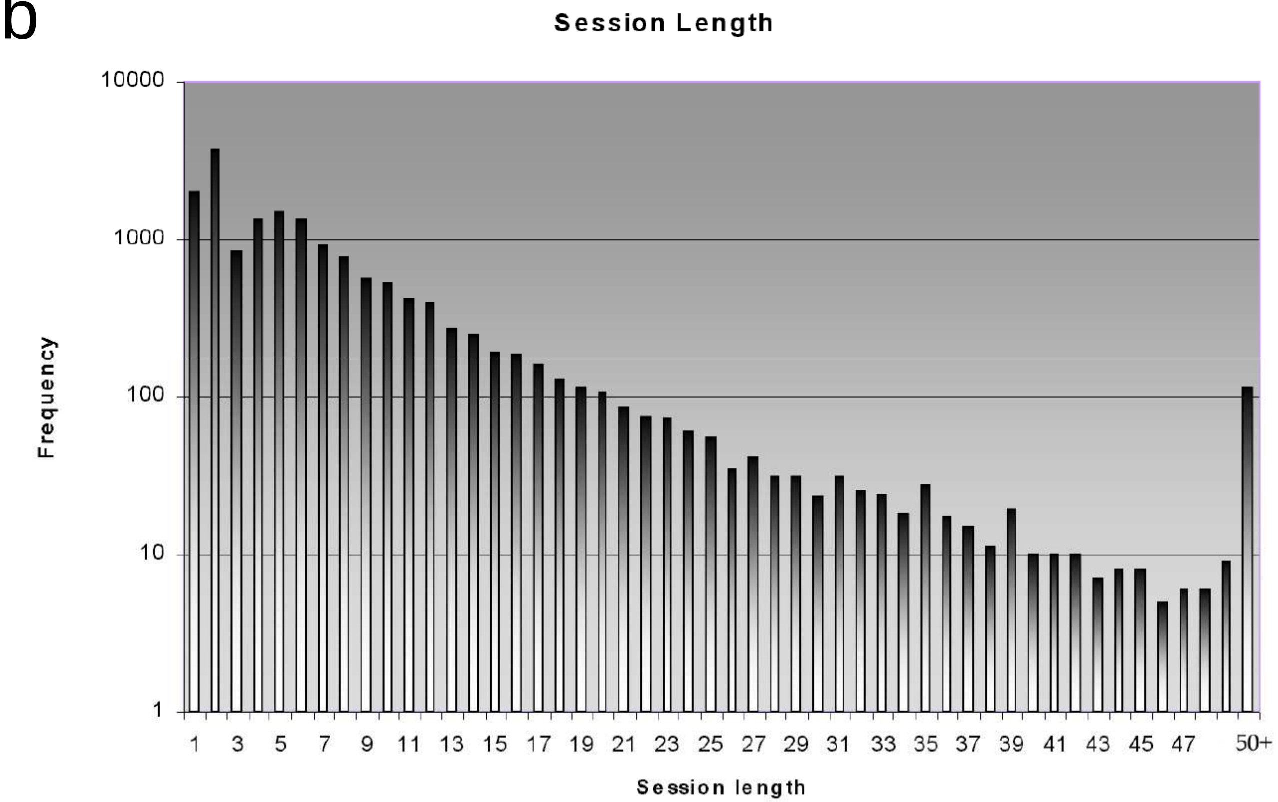
$$maxss(sl) = \sum_{i=1}^{sl}(i-1) \approx 0.5 \times (sl-1)^2$$



Subsessions starting pr click at length 50 is average 24,5

Session length - Frequency

- Average length of click sequences from Nykredits web



When considering session length frequency, the amount of subsession starting pr click is in average 3,56

Subsession Amount Optimisation (1/2)

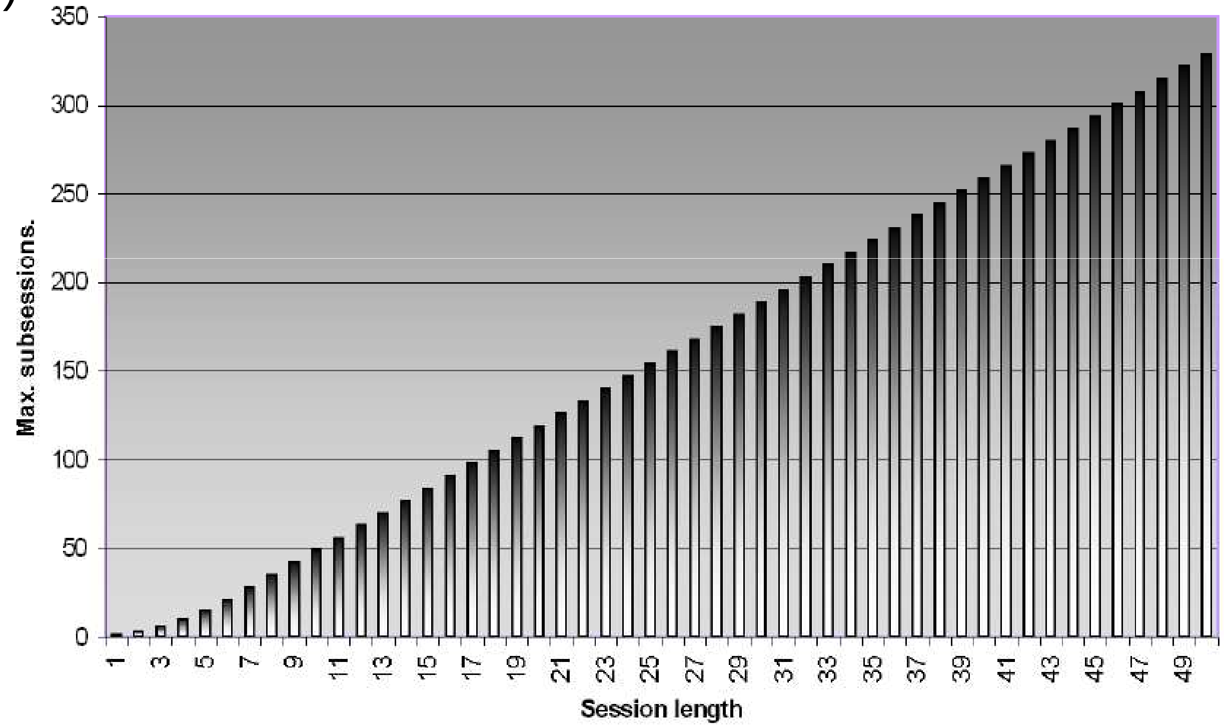
- Optimisation
  - Excluding sessions with 1-2 clicks.
    - Could be users entering the site by mistake.
    - 1 clicks sessions are already excluded by the subsession model
    - 2 clicks sessions are needed in the case
  - Setting a minimum subsession length
    - Not useful in the Nykredit case
    - Cannot answer the banner effiency question
  - Setting a max subsession length
  - Data quality cost
  - Likeliness of a given click sequence, decrease with length

$$ss(sl) = \left(\sum_{i=1}^{min(sl,maxSSL)} (i-1) \right) + (sl - min(sl, maxSSL)) \times (maxSSL - 1)$$

maxSSL = Max length of subssession, sl = length of click sequence

Subsession Amount Optimisation (2/2)

- Up to a 73% reduction in the number of subsessions
- Average amount of subsessions starting pr click is now: 2,78 (22,2% reduction)

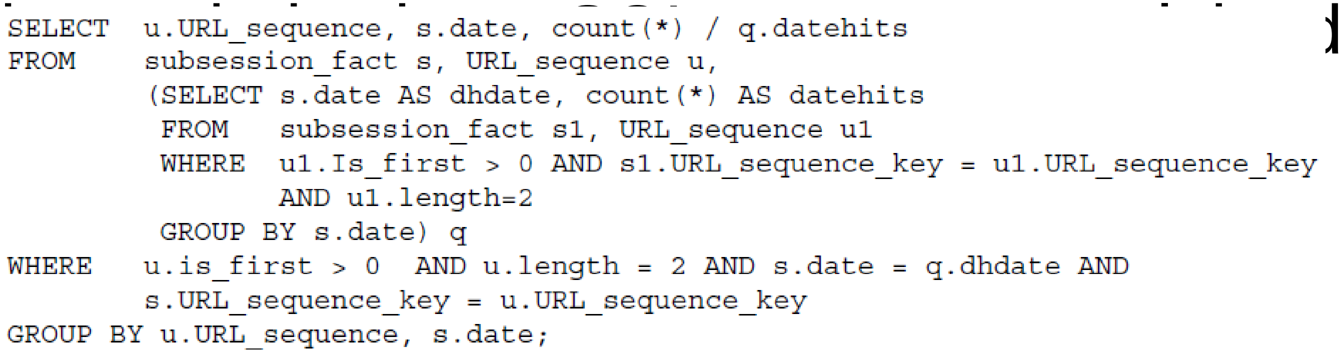


Max subsession length set to 8

Analysis - Banner optimisation

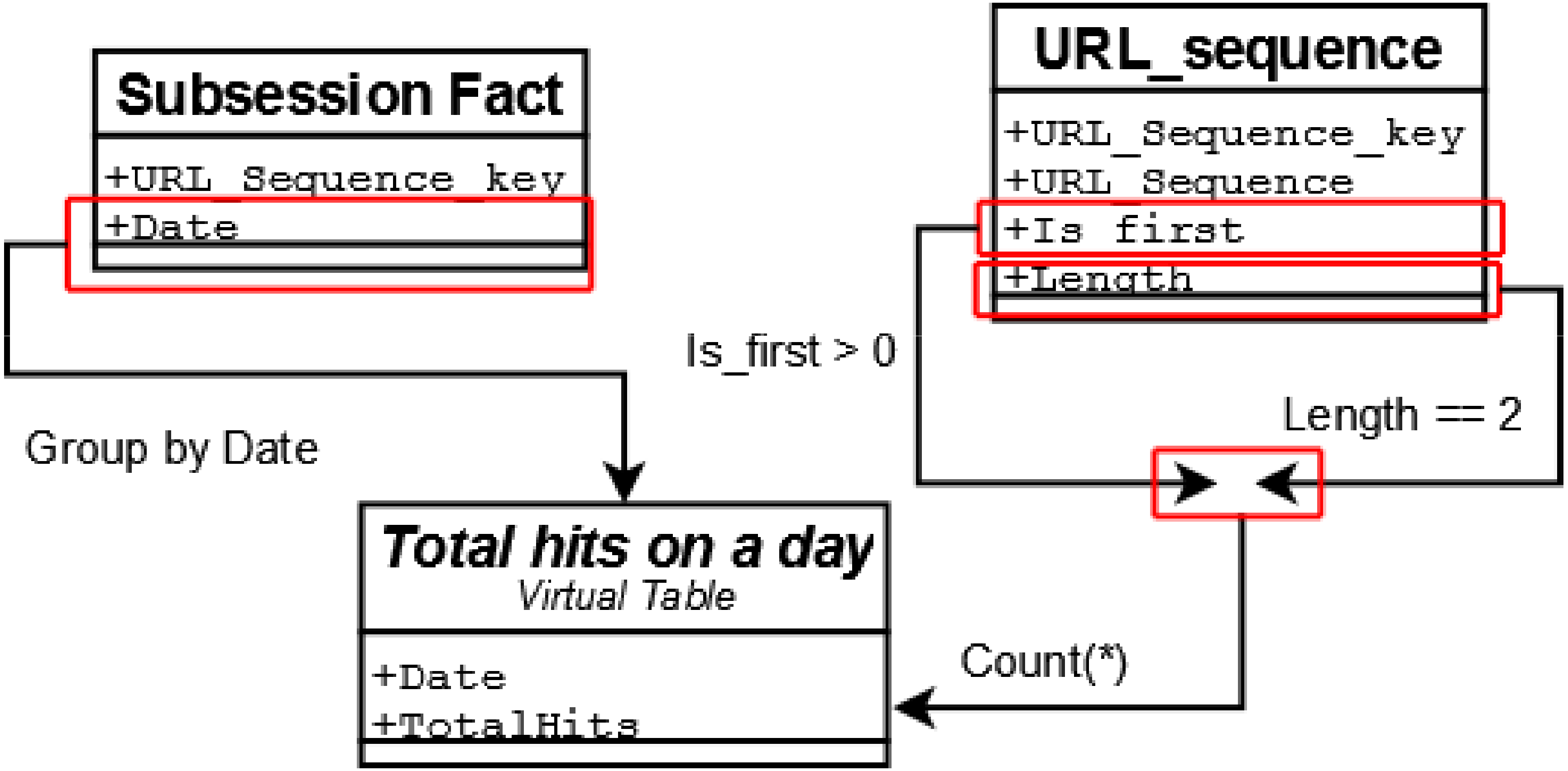
$$\mathit{HitsFromFrontPage}(page, t+1) >> \mathit{HitsFromFrontPage}(page, t-1) \Leftrightarrow$$
$$\text{A banner is set up on the front page, at the time } t\text{, pointing to } page$$

- Banner optimisation
  - Page hits from front page at a given day
  - Hit count has to be larger that a given threshold
  - Frequency of hits on a page at a given day (page, day)
- This d next

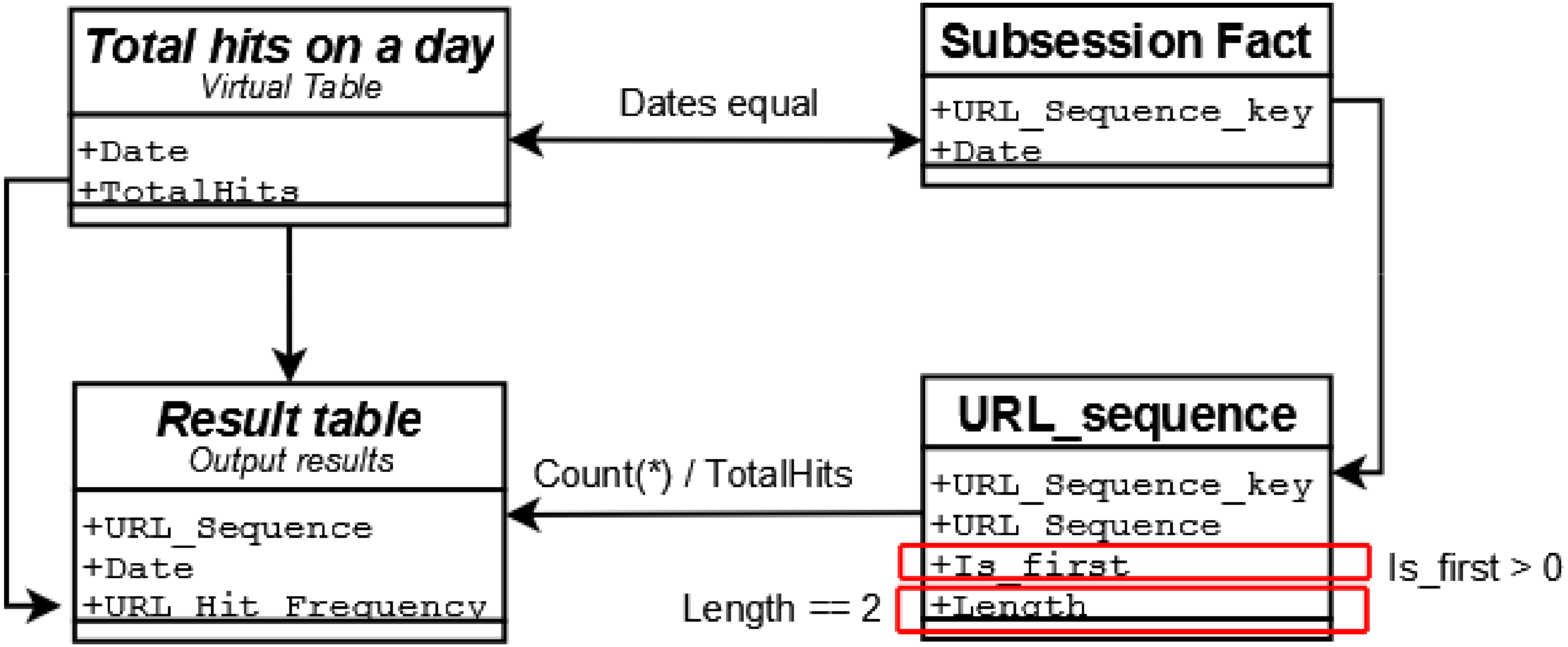


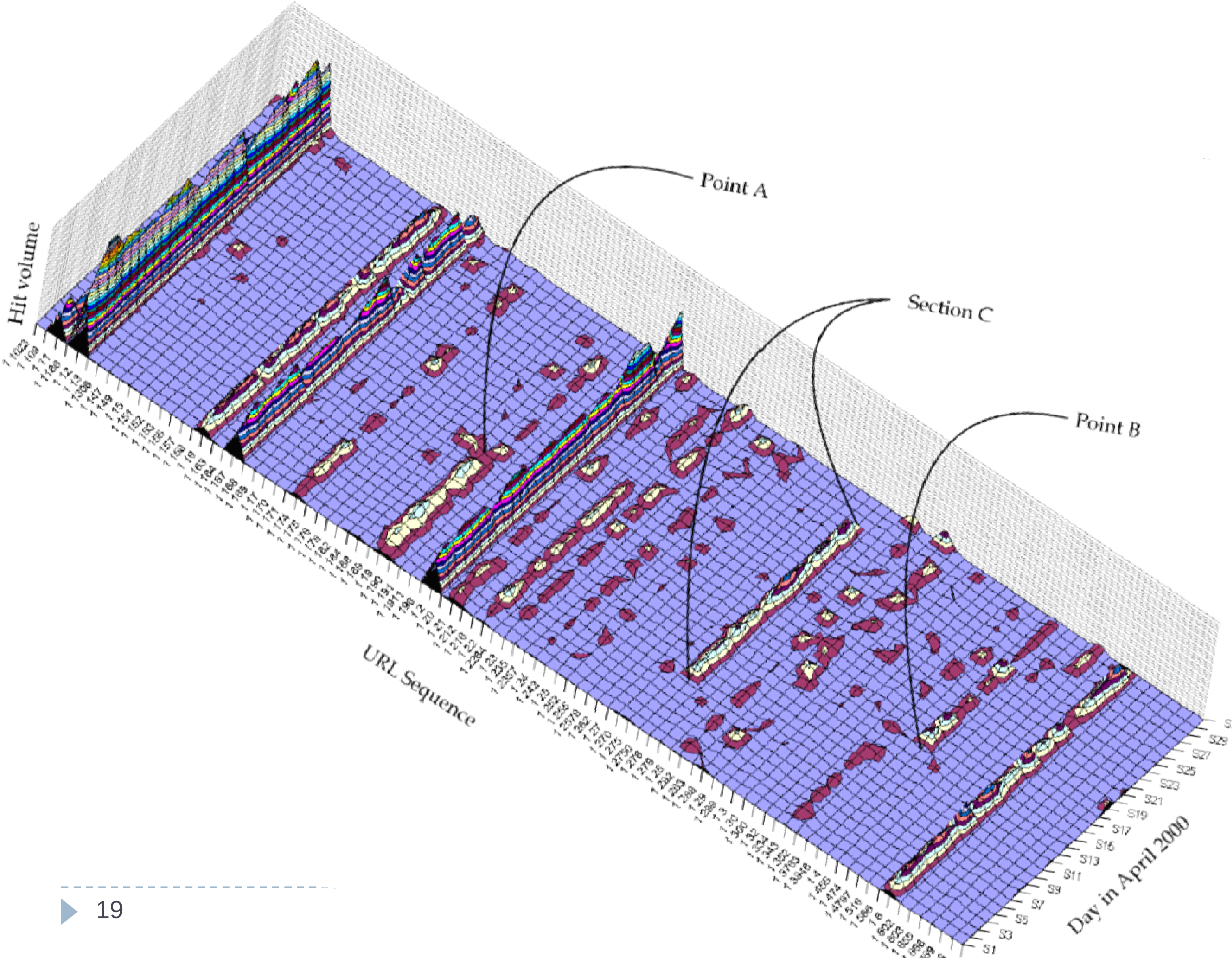
```
SELECT  u.URL_sequence, s.date, count(*) / q.datehits
FROM    subsession_fact s, URL_sequence u,
        (SELECT s.date AS dhdate, count(*) AS datehits
         FROM   subsession_fact s1, URL_sequence u1
         WHERE  u1.Is_first > 0 AND s1.URL_sequence_key = u1.URL_sequence_key
                AND u1.length=2
         GROUP BY s.date) q
WHERE   u.is_first > 0  AND u.length = 2 AND s.date = q.dhdate AND
        s.URL_sequence_key = u.URL_sequence_key
GROUP BY u.URL_sequence, s.date;
```

Example (1/2)

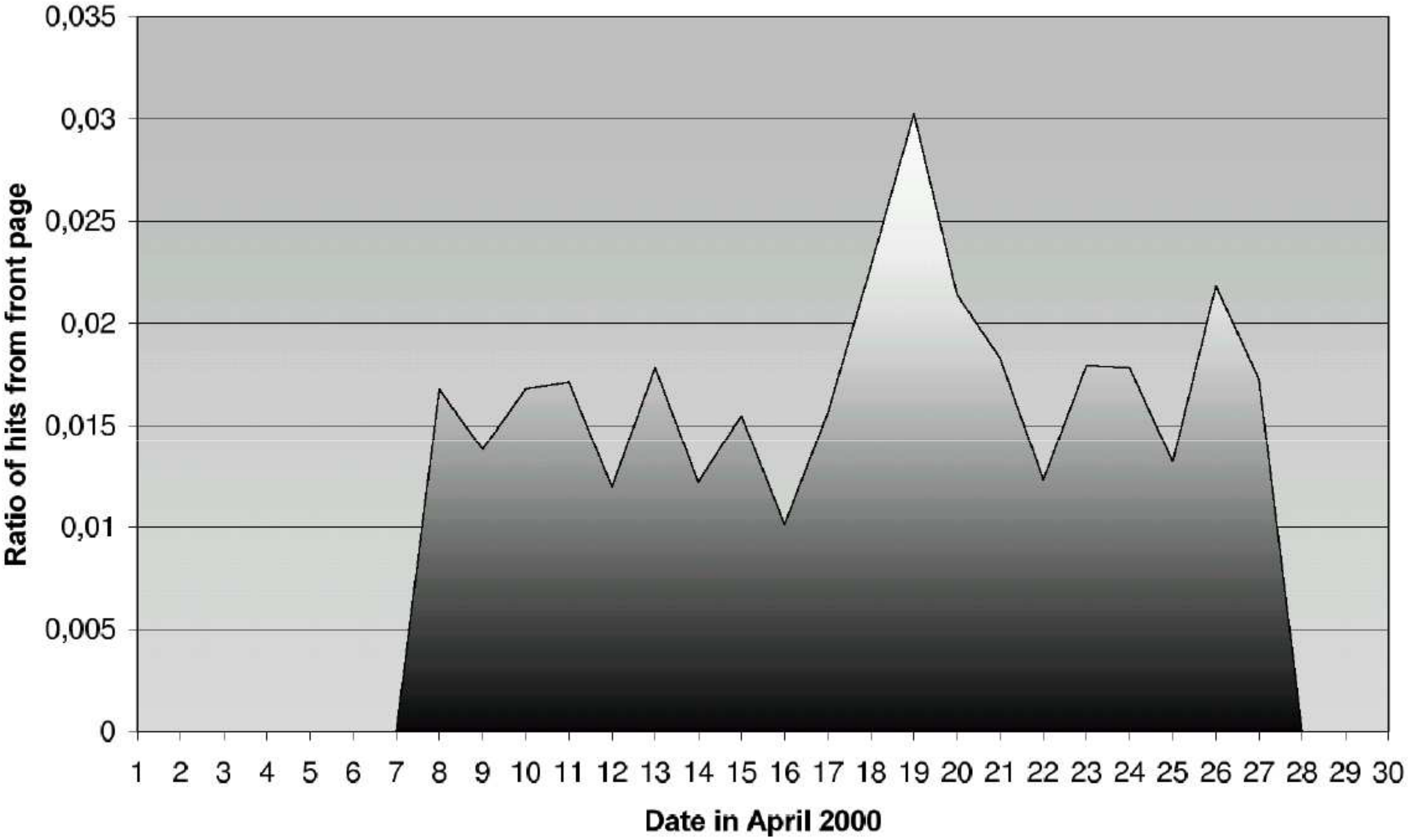

Subsession Fact
+URL_Sequence_key
+Date
URL_sequence
+URL_Sequence_key
+URL_Sequence
+Is_first
+Length
Is_first > 0
Length == 2
Group by Date
Total hits on a day
Virtual Table
+Date
+TotalHits
Count(*)

Example (2/2)


Total hits on a day
Virtual Table
+Date
+TotalHits
Dates equal
Subsession Fact
+URL_Sequence_key
+Date
Result table
Output results
+URL_Sequence
+Date
+URL_Hit_Frequency
Count(*) / TotalHits
URL_sequence
+URL_Sequence_key
+URL_Sequence
+Is_first
+Length
Is_first > 0
Length == 2


Point A
Section C
Point B
Hit volume
URL Sequence
Day in April 2000
S31
S29
S27
S25
S23
S21
S19
S17
S15
S13
S11
S9
S7
S5
S3
S1

Banner analysis 2 – Section C

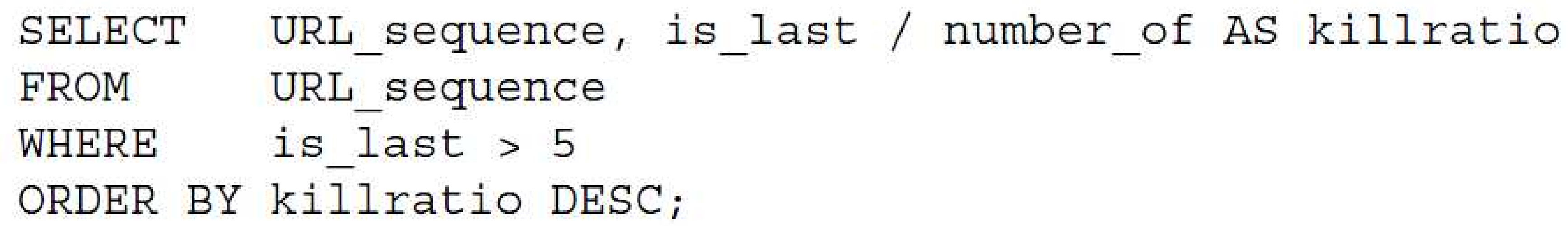


Front page banner advertisement of a online stock trading product.

Analysis - Identifying killer session

$$Sessionkills(ss)/hits(ss) > threshold \Leftrightarrow \text{The subsession } ss \text{ can be a killer subsession.}$$

- Types of killer sessions
  - Pages that have fulfilled its purpose (like a links page)
  - Pages where users switch to encrypted connection
  - Pages where users leave without fulfilling its purpose. True killer
- Can be calculated directly of aggregated data



```
SELECT   URL_sequence, is_last / number_of AS killratio
FROM     URL_sequence
WHERE    is_last > 5
ORDER BY killratio DESC;
```

Killer session graph

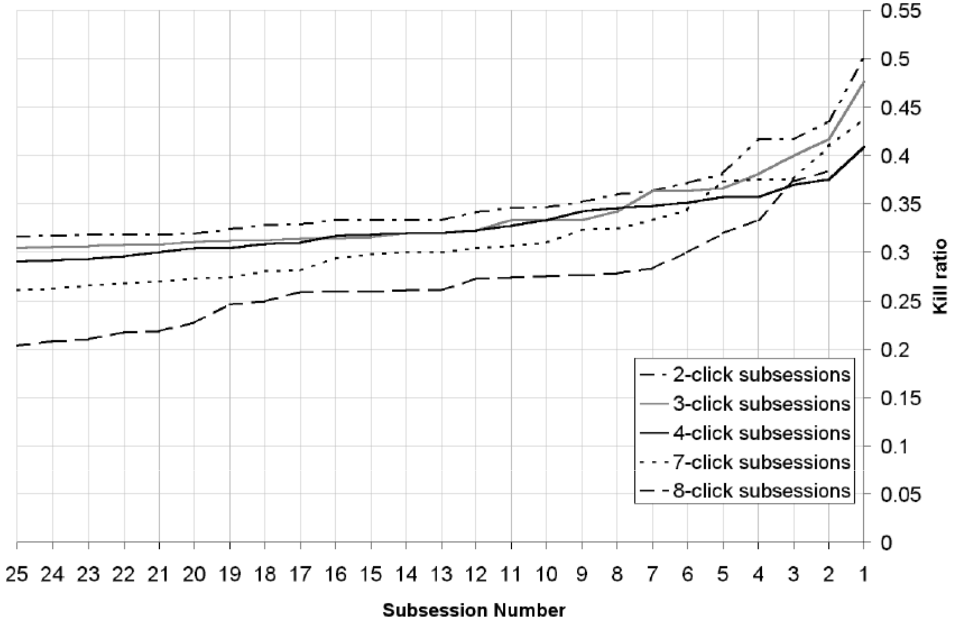


Figure 7: Killer Subsessions

- Subsessions with high kill ratio
  - URL: 13 51 520, Kill ratio 0,47 - Link page to real-estate companies
  - URL: 41 46 … 41 Kill ratio 0,44 - Circular sequence, Loan Calculator
  - URL: 3678 3679 Kill ratio 0,43 - Ends in a gigantic form

Conclusion

- They have proposed a new model
- Successfully shown it can solve the case problems
- Nykredit implemented this model after their were done

- Evaluation
  - Easy to read
  - Good flow
  - Interesting paper

Related to our work

- Our project is about tracking people in an airport
  - At the moment we analyse:
    - Where people spend time (dwell time)
    - We track the dwell time over time
    - The distribution of dwell time over tracking locations.
  - We have not looked that much into sequence analysis
  - But this model could be used for this.