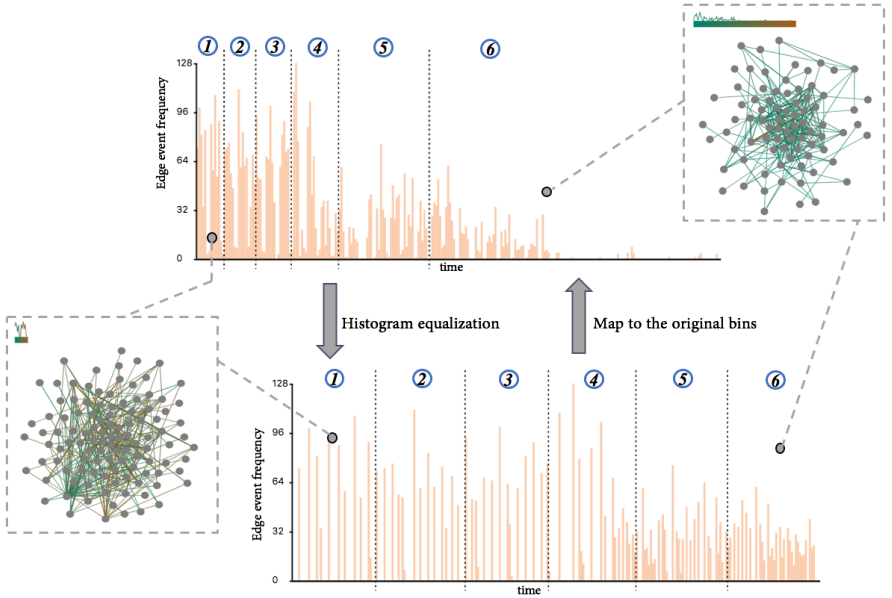


Nonuniform Timeslicing of Dynamic Graphs Based on Visual Complexity

Yong Wang[1], Daniel Archambault[2], Hammad Haleem[1], Yanhong Wu[3], Torsten Moeller[4], Huamin Qu[1]

http://yong-wang.org/proj/nu_timeslicing.html

1 香港科技大學 THE HONG KONG UNIVERSITY OF SCIENCE AND TECHNOLOGY

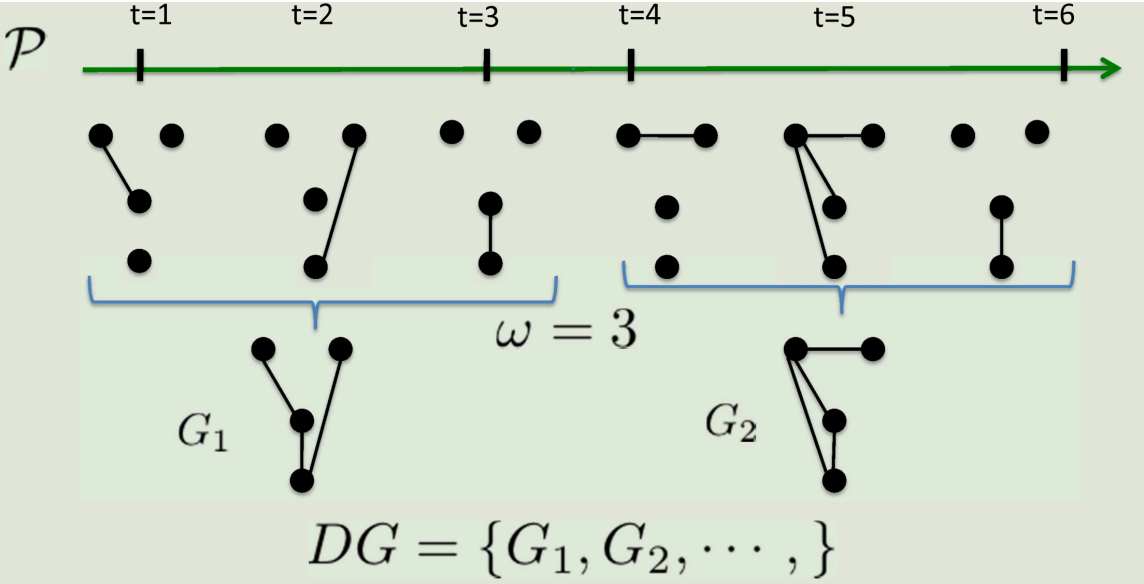
2 Swansea University Prifysgol Abertawe

3 VISA

4 universität wien

Background

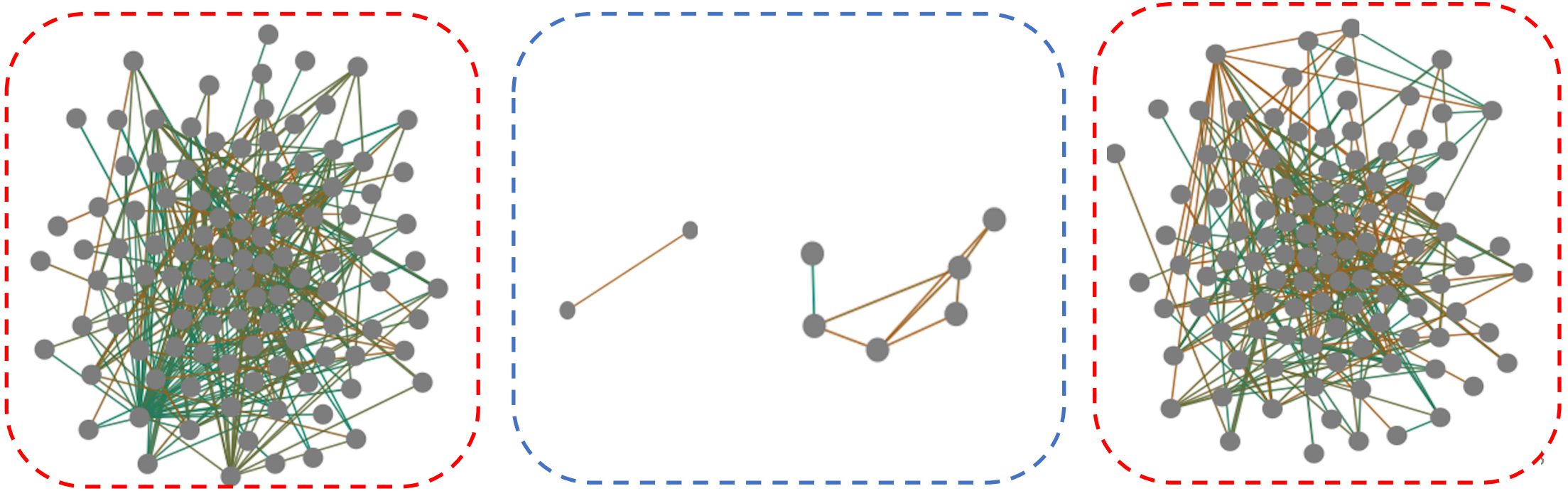
- A dynamic graph is a sequence of graph snapshots defined over an edge stream



- Uniform timeslicing divides time into equal intervals and is usually used in dynamic graph visualization for convenience and simplicity

Background

- For dynamic graph visualization, uniform timeslicing:
  - Does not take the data into account
  - Can generate cluttered timeslices with bursting edges, and empty timeslices with few edges



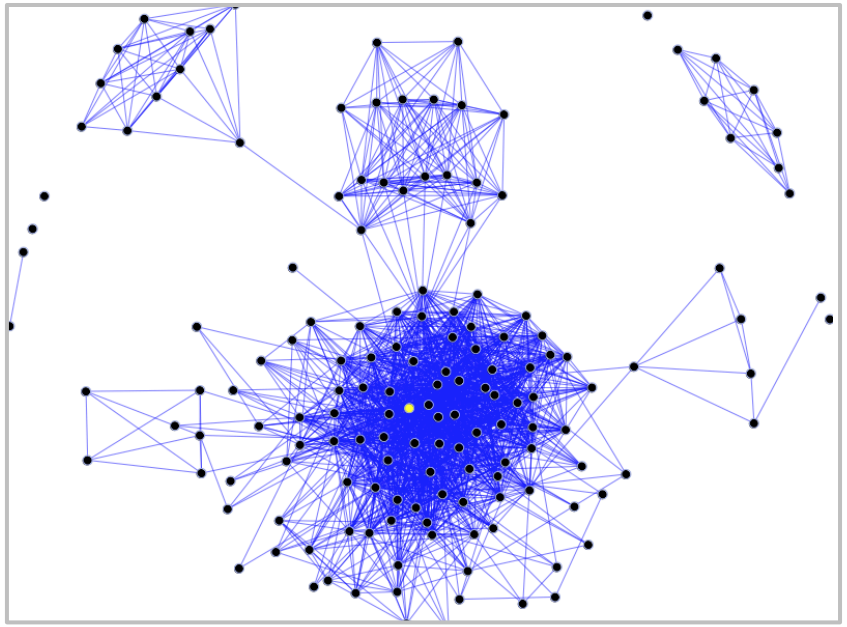
Research Problem

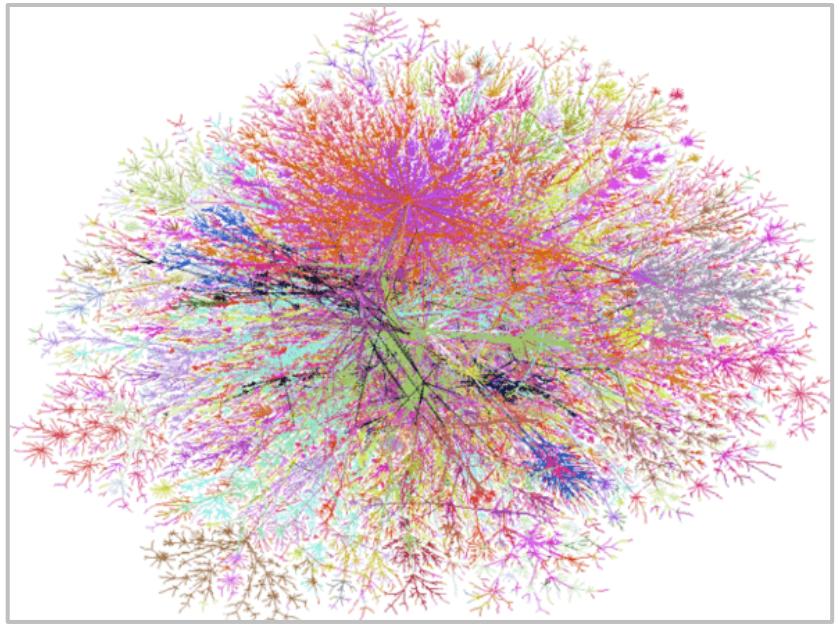
- How can we make full use of the limited number of timeslices to show more meaningful information?

- How can we provide users with better perception of the dynamic graph (especially the periods with bursting edges)?

Nonuniform Timeslicing

- Goal: create timeslices of similar visual complexity

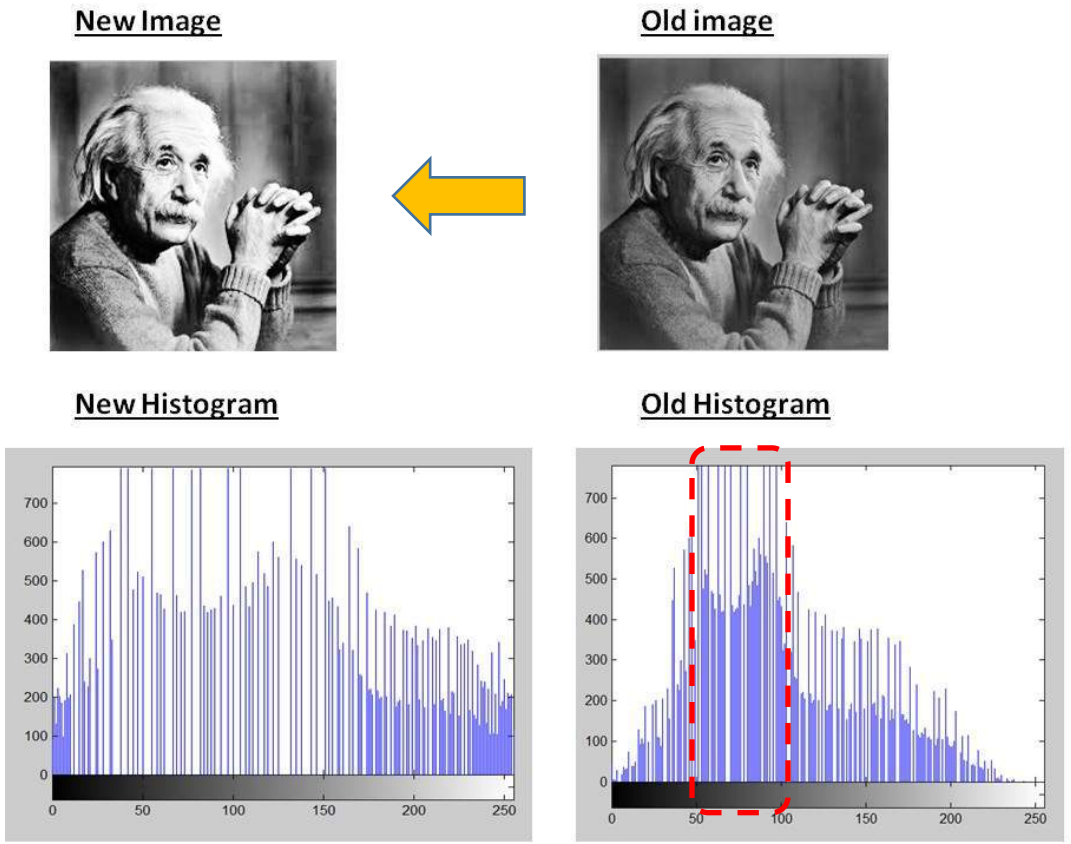




A simple definition of visual complexity: number of edges

Nonuniform Timeslicing

- Solution: nonuniform timeslicing based on histogram equalization, a technique for enhancing image contrast



https://www.tutorialspoint.com/dip/histogram_equalization.htm

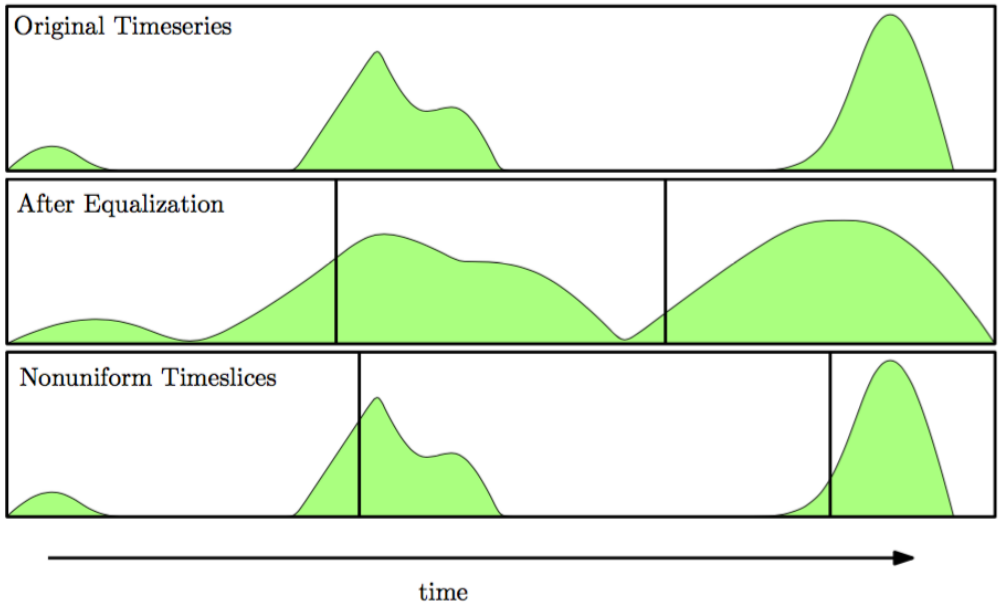
Nonuniform Timeslicing

- Image contrast enhancement vs. dynamic graph visualization

	Image Contrast Enhancement	Dynamic Graph Visualization
Problems	Low color contrast	Visual clutter in some timeslices
Causes	Color convergence in certain color range	Edge bursting in certain time range
Solutions	Re-distribute color bins for equal distribution	How ???

Nonuniform Timeslicing For Dynamic Graphs

- Adapt histogram equalization to redistribute edge counts across time



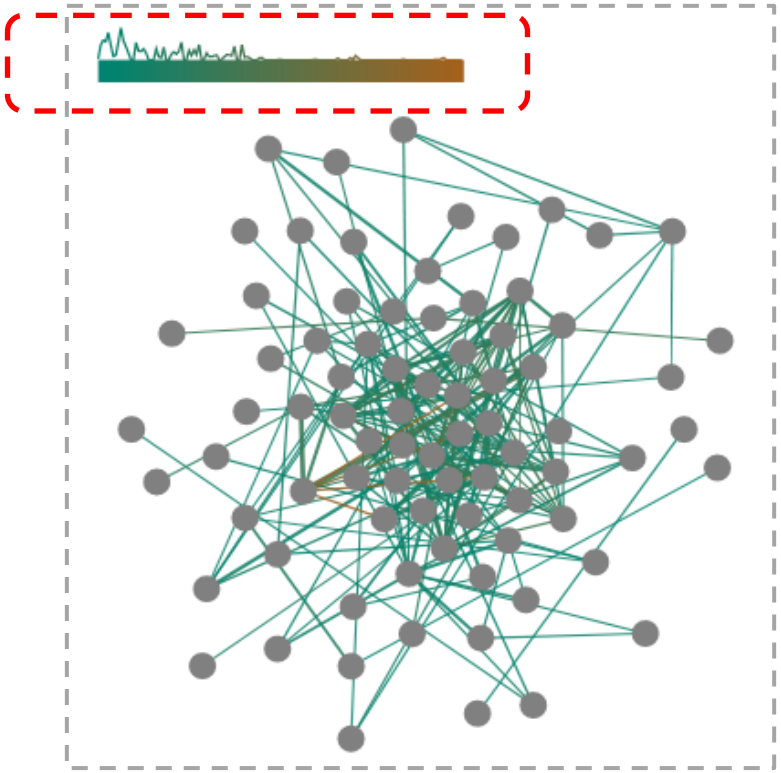
For the $i\text{-}th$ bin in the original time series, histogram equalization will transform it to the following bin:

$$s_i = \lfloor (T-1) \sum_{j=0}^{i} p(j) \rfloor$$

Where $p(i) = |E_i|/|E|$, T is the total time range, E_i is the number of edge events in the $i\text{-}th$ bin and E is the total number of edge events.

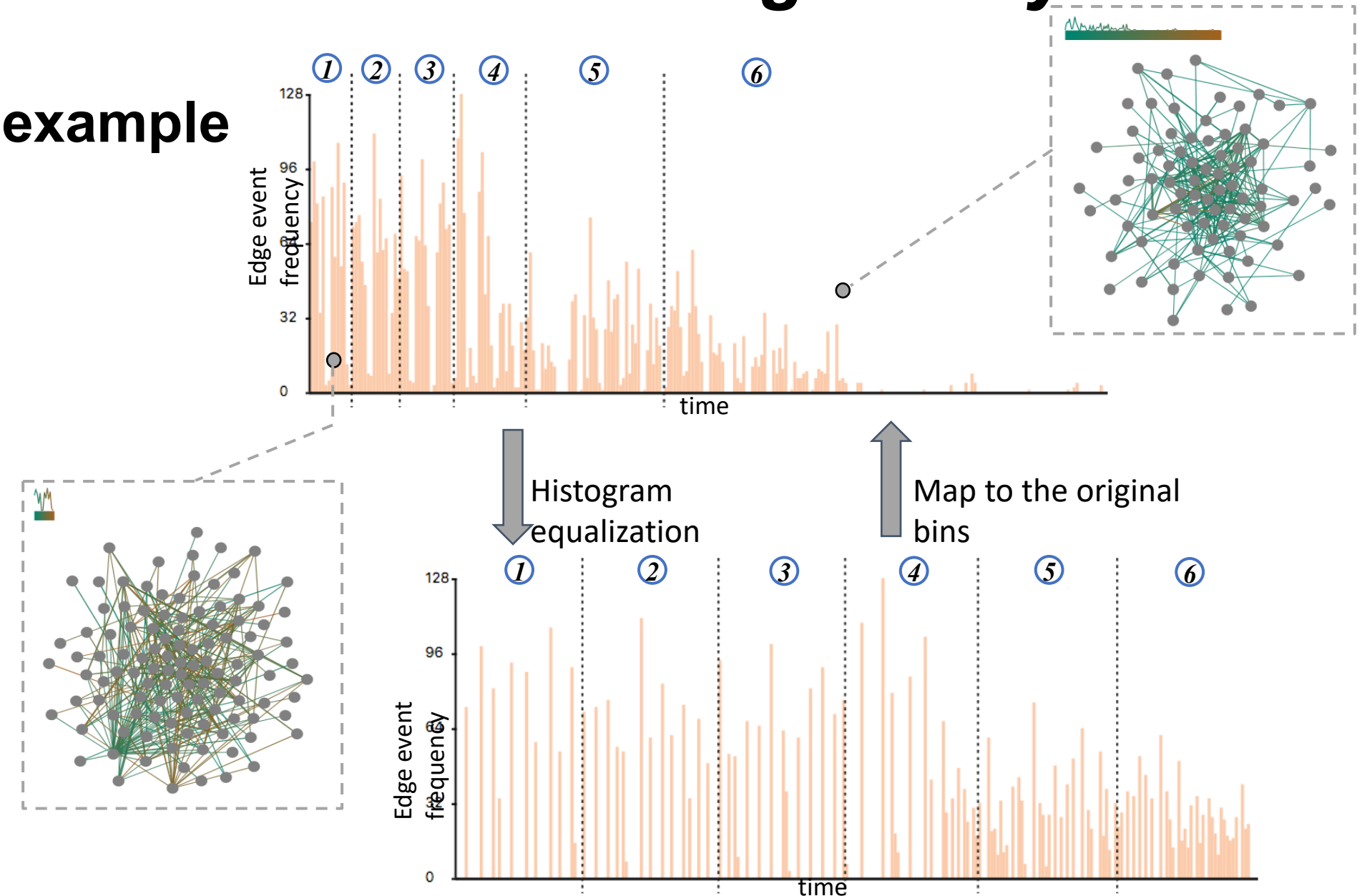
Nonuniform Timeslicing For Dynamic Graphs

- Visual hint for time information
  - An explicit time legend for each graph snapshot



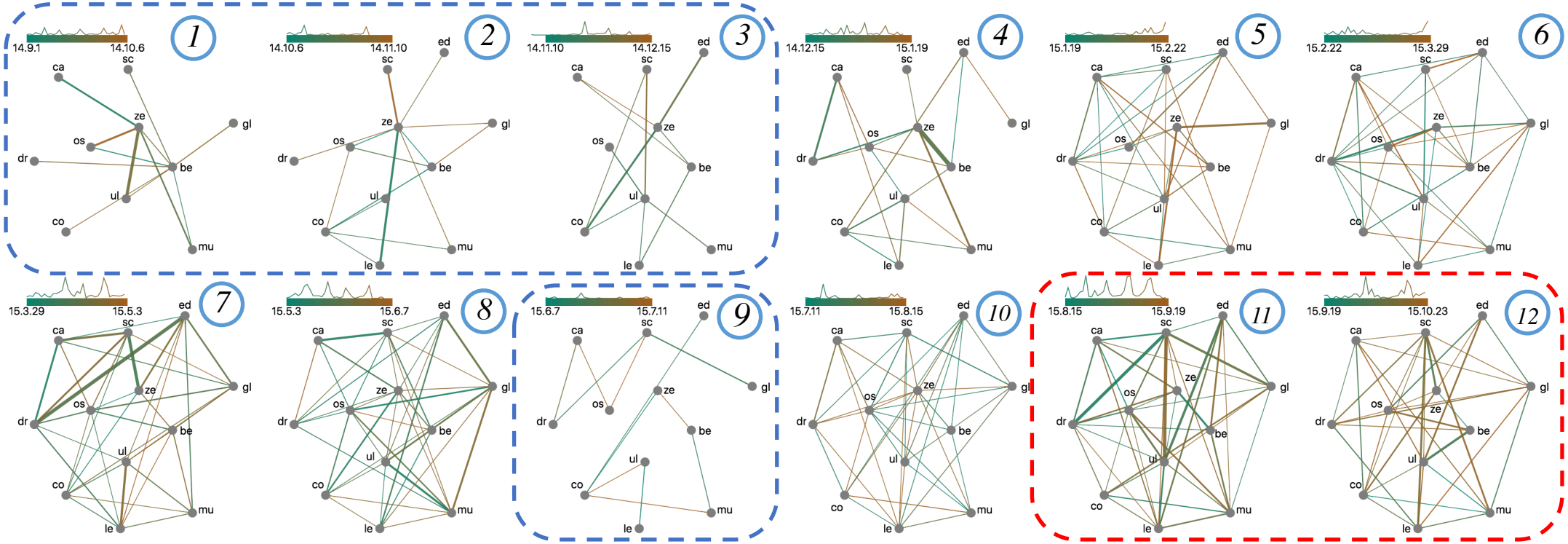
Nonuniform Timeslicing For Dynamic Graphs

One example



Evaluation – Qualitative Case Study

- Rugby dataset --- uniform timeslicing

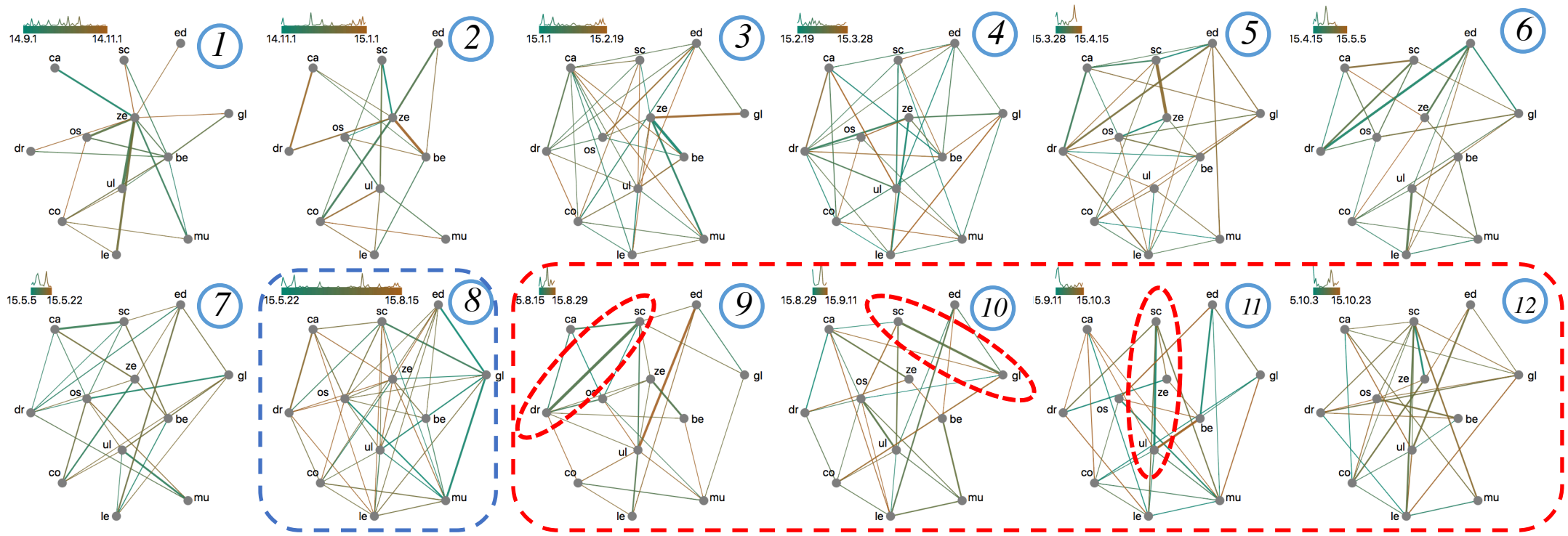


- Intervals1, 2, 3, 9: sparse edges
- Intervals 11, 12: dense edges, hindering users from checking details

https://arxiv.org/abs/1709.00372

Evaluation – Qualitative Case Study

- Rugby dataset --- nonuniform timeslicing

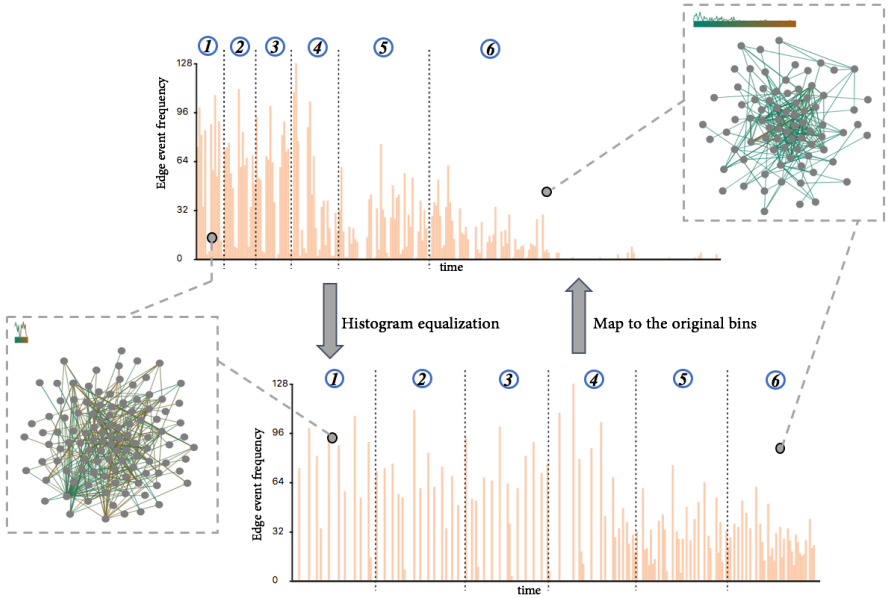


- Intervals 8: sparse interactions (summer break from may to August)
- Intervals 9-12: dense interactions (the season begins)
- Reveal more details: "***sc***" interacted most with different teams along time

Summary and Discussion

- Compared with uniform timeslicing, the proposed nonuniform timeslicing can achieve
  - Balance visual complexity across intervals
  - Reveal more details in the intervals of bursting edges

- Limitations
  - Scalability issues: visual clutter can be reduced but cannot be always removed
  - Application: more suitable for dynamic graphs with edge event variations



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