

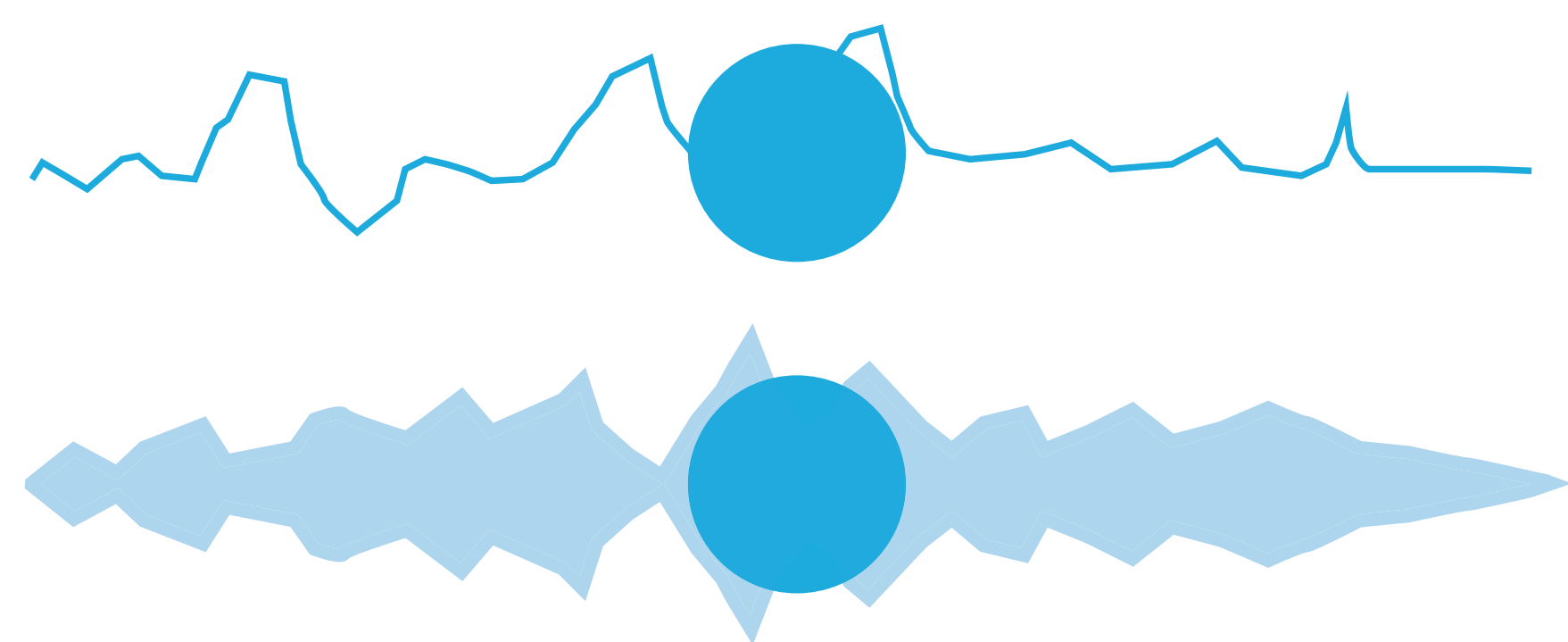
Timelines are as important for presenting temporal data as node-link diagrams are relevant for displaying graphs. Both are rarely combined due to layout restrictions a spatial timeline imposes, and challenges with unambiguous node placing. Also, common overview and detail visualizations face problems with edges that connect temporal distant nodes. We introduce Time Shadows and Time Beads to alleviate these problems.

Time Shadows

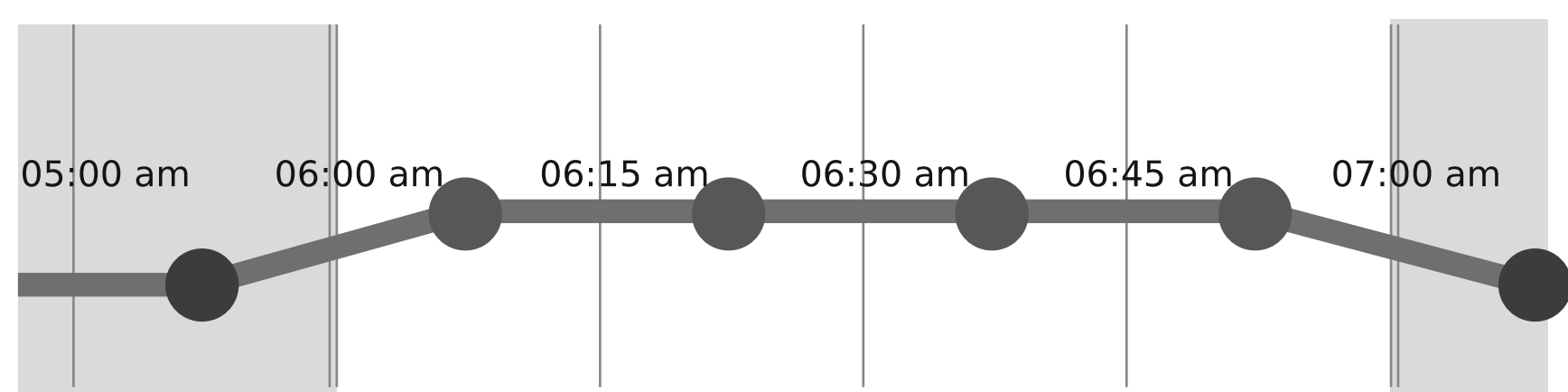
The Time Shadow is a semi-transparent shape behind a graph node that visualizes the **duration of an item**, e.g. the lifetime of a person.

Advantages of Time Shadows:

- Improving the understanding of implicit, **temporal relations of elements** in node-link diagrams
- Precisely defining start, duration and end of a time interval (or blurring to indicate ongoing intervals)
- **Visualizing quantitative data** using sparklines or polygons
- Keeping the meaning of the graph intact and not hindering edge layout



Time Shadows can visualize quantitative data, e.g. stock prices or an artist's productivity.



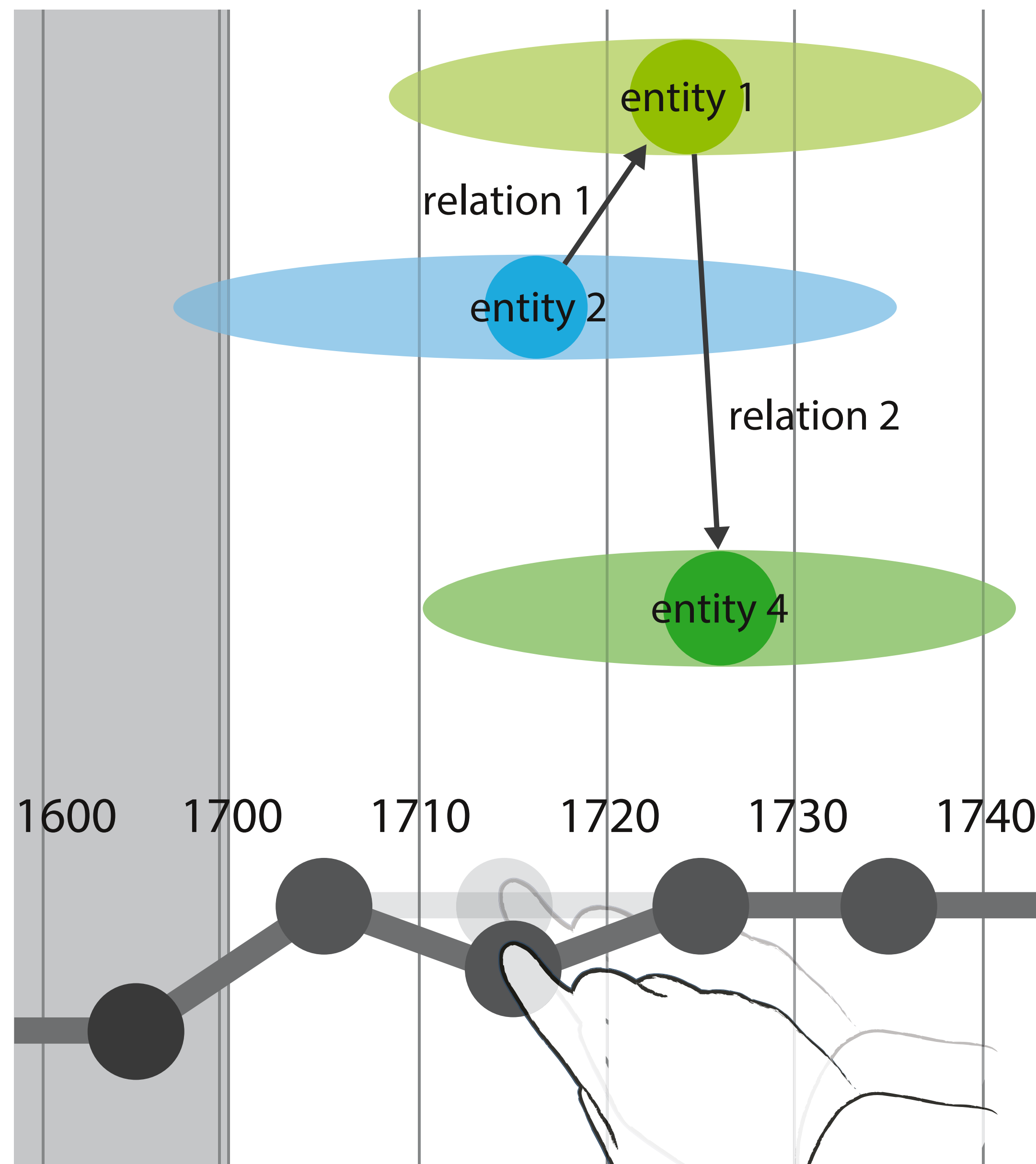
Time Beads are based on a tree structure. A Bead can be popped to view its children.

User study

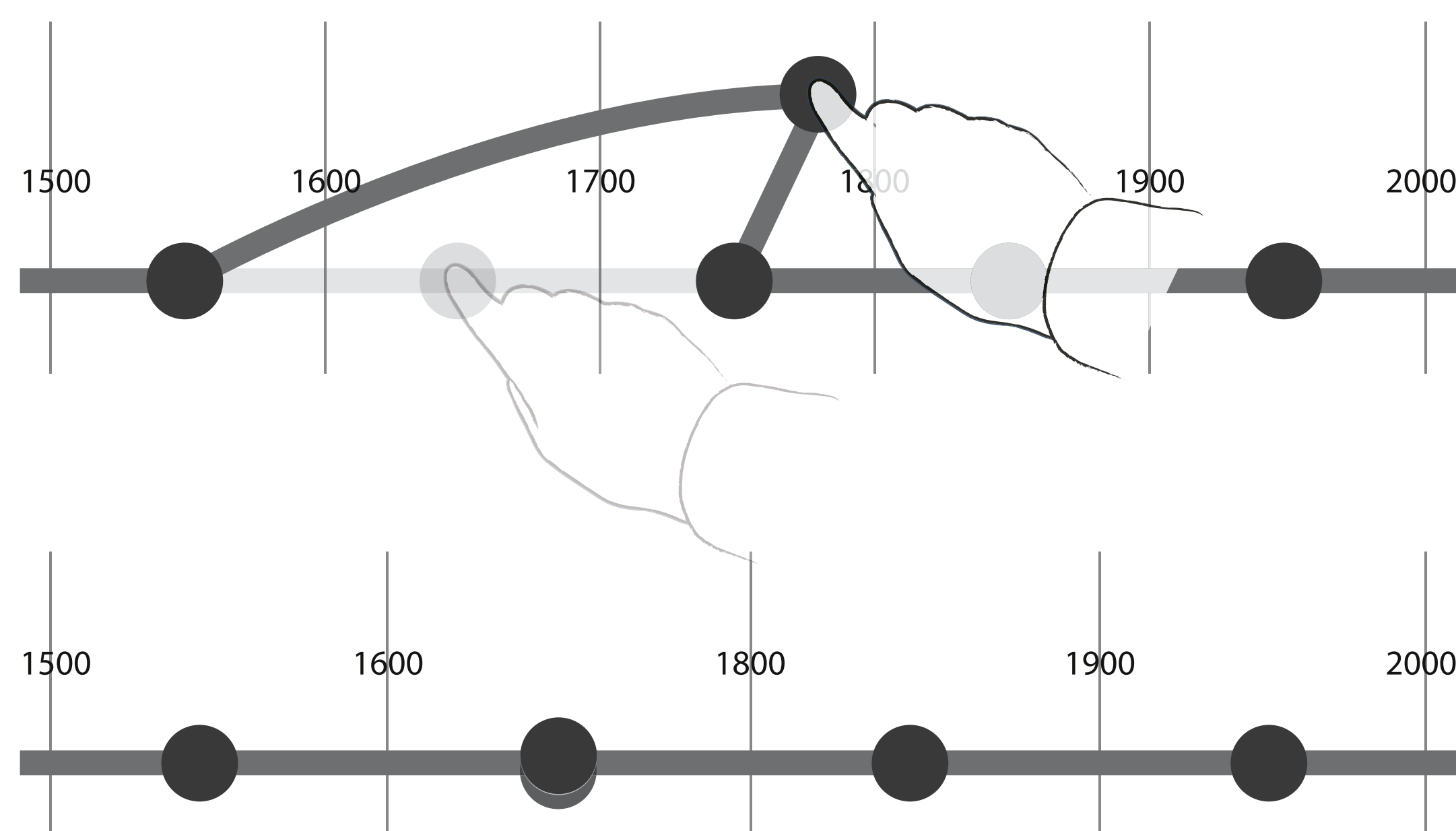
We developed a Java-based prototype to display **semantic data** of the DBpedia project, stored on a local Fuseki server.

Features of the prototype:

- Displaying the semantic network of a pivot node like Albert Einstein
- Data exploration by shifting the pivot node
- **Creating focus regions** using Time Beads
- Visualizing temporal data and semantic relations using horizontal and vertical position



Time Shadows (top) and Time Beads (bottom) visualize semantic data. The user can interact with the Time Beads to enlarge or to compress time intervals.



Time Beads can be stacked manually by dragging one Bead over another, compressing the timeline.

Time Beads

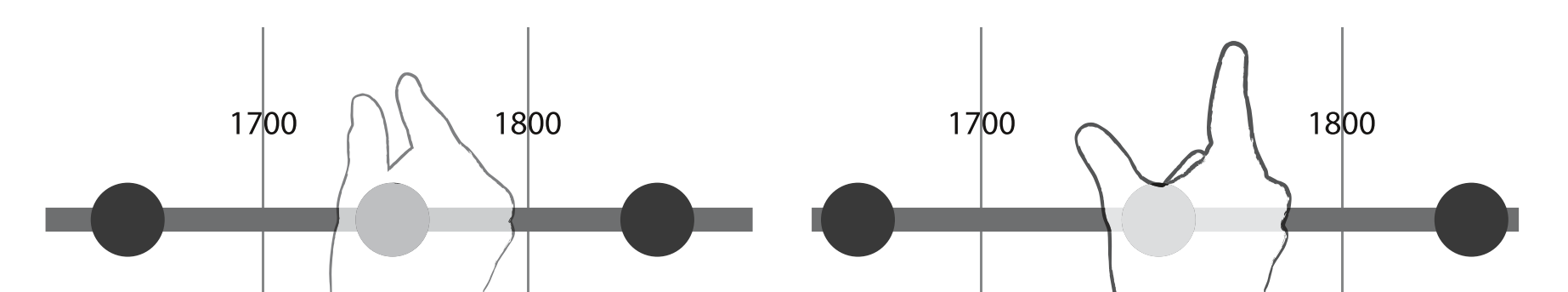
Time Beads are both a visualization technique and a **focus-and-context interaction** technique. Each Time Bead is a node that represents one arbitrary time interval. They are chained at the lower edge of the screen as a timeline.

Time Beads are an efficient interaction technique, offering:

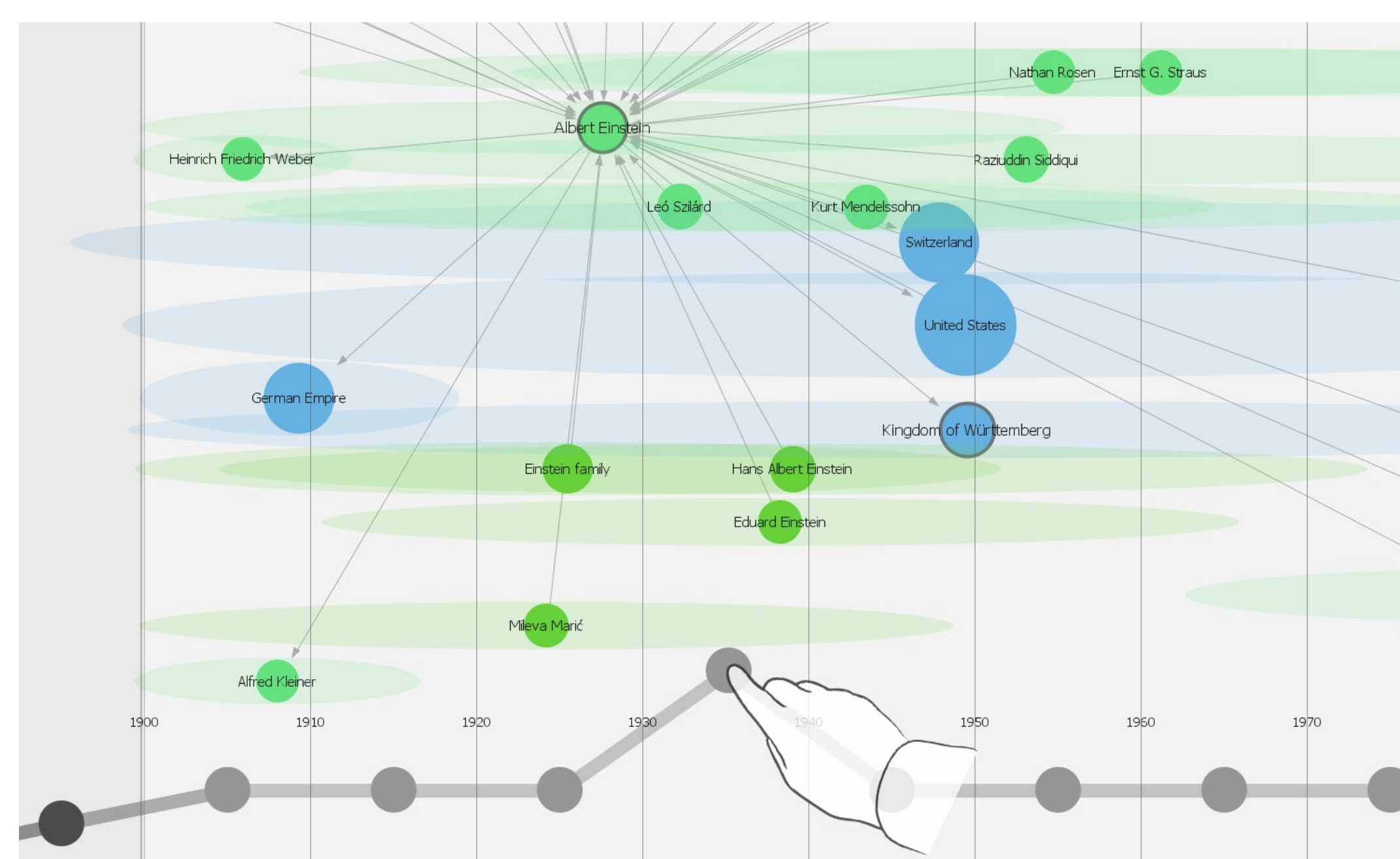
- Displaying the whole graph onscreen to encourage pattern recognition
- **Focusing multiple time intervals** in different levels of detail to enable comparisons
- **Discrete navigation** using the Beads and **continuous navigation** using stretching gestures to accomplish time specific tasks

Techniques to manipulate Time Beads:

- Dragging intervals up or down to open or close hierarchical layers
- **Stacking intervals** on each other or at the edge of the screen to compress unimportant time intervals
- Stretching or compressing one or multiple intervals using two fingers



Single and double handed spreading gestures can stretch one or more intervals.



The prototype Nornir, displaying the graph with Time Shadows, the Time Beads and a sidebar

We observed that the participants required some settling in to identify Time Shadows as a indicator of lifetime. Afterwards, they **relied on Time Shadows** to read the graph and its relations.

The study participants regarded the Time Beads concept as useful, but asked for more multitouch interaction on the white-space. With the presented improvements, Time Beads are a flexible tool for exploring and analysing temporal graph data.