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ENHANCING CONCEPT MAPPING TOOLS BELOW AND ABOVE TO FACILITATE THE USE OF SUPERIMPOSED INFORMATION

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Abstract. In this paper, we describe ways of enhancing concept mapping tools to facilitate representation and use of *superimposed information.* Superimposed information refers to new interpretation of existing information and involves working with information at various document granularities (sub-document, complete document, and multi-document). We illustrate our approach by showing how enhanced concept mapping tools may be used with two superimposed applications: SIMPEL and Strand Maps.

1 Introduction

Concept maps are used to represent an individual/group's understanding of something (e.g., an idea, a domain of knowledge, a topic). In many applications, like teaching and research, concept maps can be considered to be new interpretations of existing information. For example, when a student is trying to write a paper, she could annotate information resources, and organize various annotations and references into a concept map that may represent the outline of the paper that she is trying to write. She also may attach relevant resources (including multimedia content) to concepts to provide more detailed information or to remind her of the works associated with various concepts. Thus, in some sense, she is *superimposing* new information (the concept map and annotations) over existing information (references used).

In research and other scholarly activities, we rarely treat all parts of a document (information resource) in a uniform manner. When building concept maps, a concept (or group of concepts) often refers to a part of a document. Although current concept mapping tools like IHMC CmapTools (Cañas, A. J., Hill, G. et al. 2004) and GetSmart (Marshall, B., Zhang, Y. et al. 2003) allow users to build concept maps and attach multimedia resources, they are limited in their ability to reference information at sub-document granularity. We believe that such a capability can be useful in many applications.

In this paper, we present an approach to enhance concept mapping tools using the idea of *superimposed information*. We demonstrate our approach by enhancing the IHMC CmapTools in two ways: *below* – by providing a mechanism to reference information at sub-document granularity, and *above* – by introducing some additional modeling and knowledge management constructs and tools that can help represent superimposed information. We illustrate these enhancements using two example superimposed applications.

2 Superimposed Information

Superimposed information (SI) refers to new interpretation of existing information (Maier, D. and Delcambre, L. 1999). This could be in the form of new content – like annotations, comments, etc. – or new structures – like tables of contents, concordances, back of the book indexes (an example of hierarchical list structures), or concept maps (graph structures). Superimposed applications (SAs) allow users to overlay new interpretations over existing or *base information*, typically to highlight, annotate, elaborate, select, collect, organize, connect, or reuse information elements. SAs employ "marks", which are references to selected regions within base information (of text or multimedia content) that also may carry media-specific summaries (e.g., text abstracts, image thumbnails).

SAs may make use of the Superimposed Pluggable Architecture for Contexts and Excerpts (SPARCE), middleware that provides mark management and other services (Murthy, S., Maier, D. et al. 2004). Information in marks includes document format information (e.g., HTML, PDF, media file formats like .WMV), an address for the containing document, and a specification of the location of the selected region within that document. It also includes mark creation properties like mark creator, as well as timestamp and

machine-specific information. Marks may be used to obtain the excerpt (content) and the context (properties like font size, whether the selected region is a hyperlink, etc.) of the selected region. Marks can be referred to, manipulated as first class objects, and resolved (bringing back the "base level" document with the marks highlighted in a way suitable for the particular type of media involved).

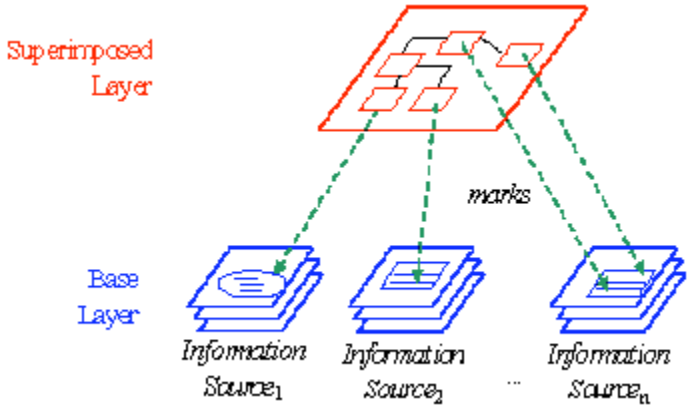

Figure 0. (Source: (Murthy, S. and Maier, D. 2003)) Layers of information and marks in an SI system.

Figure 1 shows the different layers of information and marks in an SI system. Information (documents) in the superimposed layer usually follow a structure (e.g., schema) specified by the SA, sometimes referred to as the superimposed structure. SAs enable us to (a) deal with information at varying granularity (sub-document, complete document, and multi-document), and (b) select or work with information elements at sub-document level while retaining the original context (by referencing information, not replicating).

3 Enhancing IHMC CmapTools to Provide Support for SI

Concept maps represent a type of superimposed information. Current concept mapping tools like IHMC CmapTools (Cañas, A. J., Hill, G. et al. 2004) and GetSmart (Marshall, B., Zhang, Y. et al. 2003) have certain features that allow them to be used as a superimposed application. For example, they allow:

- Representation of SI using concepts and links
- Connecting concepts and links (superimposed information) to resources (base information) at complete document and multi-document levels (attaching one or more resources to a concept/link)

However, these tools are limited in their capability to reference/link information at the sub-document level. In addition, they still need a method to represent superimposed structure, or the structure of an SI document.

We believe that by enhancing concept mapping tools *below* and *above*, we can provide these capabilities to better support an SI system. By enhancing *below*, we mean providing capability to connect concepts and linking phrases to information at sub-document granularity. One way to achieve this is by treating marks as resources. By enhancing *above*, we mean enabling concept mapping tools with capabilities to represent richer semantics and structure, and make them more expressive, in order to represent superimposed structures. We believe that this may be accomplished by allowing concepts and linking phrase constructs to represent additional structures that go beyond the proposition structure (concept-linking phrase-concept).

We are working towards providing SI support in IHMC CmapTools. Currently, we have taken advantage of the URI representation of a mark (explained in (Murthy, S. 2005)) and use it as a web address resource in CmapTools. As shown in Figure 2, this enables connecting of concepts and links to information at the sub-document level. In Figure 2, the concept “hypertext” is connected to a mark (describing the concept) within an HTML document.

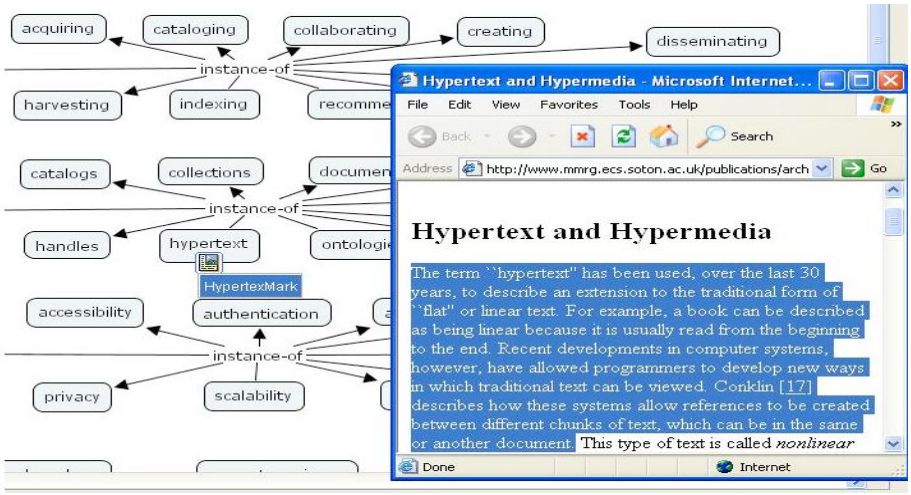

Figure 2. A section of a concept map on "Taxonomy of Digital Library Terms". The concept "hypertext" has a mark attached that points to a section describing hypertext in an HTML document (shown highlighted in blue).

To demonstrate how concept mapping tools may be enhanced *above*, we show how CmapTools may be used with two superimposed applications – SIMPEL and Strand Maps. Note: these enhancements are to a concept mapping tool, namely, the IHMC CmapTools, and not necessarily to the concept map model.

3.1 SIMPEL

```
<presentation>
  <name>Memex.xml</name>
   <location>D:\SIMPEL</location>
   <begin_time>
     <value>1</value>
     <item>
       <id>2005_12_1_16_14_53_718_MemexAudio</id>
       <name>MemexAudio</name>
       <mark_id>WMPMediaMark2005Dec01161413EDUCATIOQY40U5KapilAhuja</mark_id>
       <span_time>43</span_time>
       <channel_id>PaneA</channel_id>
     </item>
   </begin_time>
   <begin_time>
     <value>2</value>
     <item>
       <id>2005_12_1_17_13_24_15_BushText</id>
       <name>BushText</name>
       <mark_id>HTMLMark2005Dec01171301EDUCATIOQY40U5KapilAhuja</mark_id>
       <span_time>10</span_time>
       <channel_id>PaneC</channel_id>
     </item>
   </begin_time>
 </presentation>
```

Figure 3. A section of the XML representation of a SIMPEL presentation describing Vannevar Bush's Memex

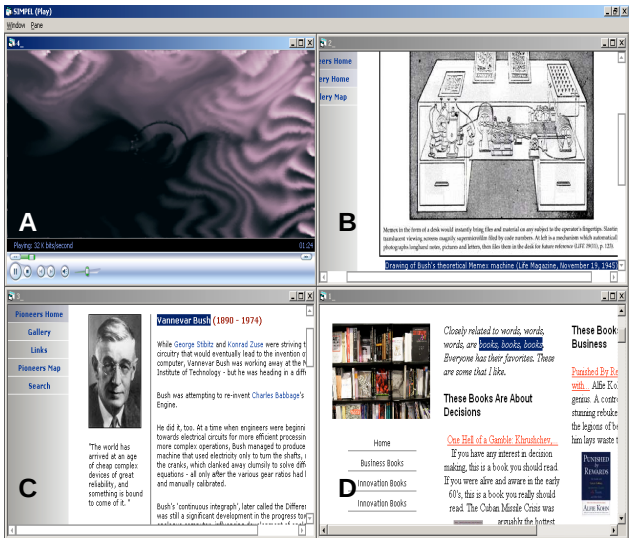

Figure 4. The SIMPEL "play" interface, showing a presentation describing Vannevar Bush's Memex. Pane A contains an audio clip. Panes B, C, and D show selected information within web pages.

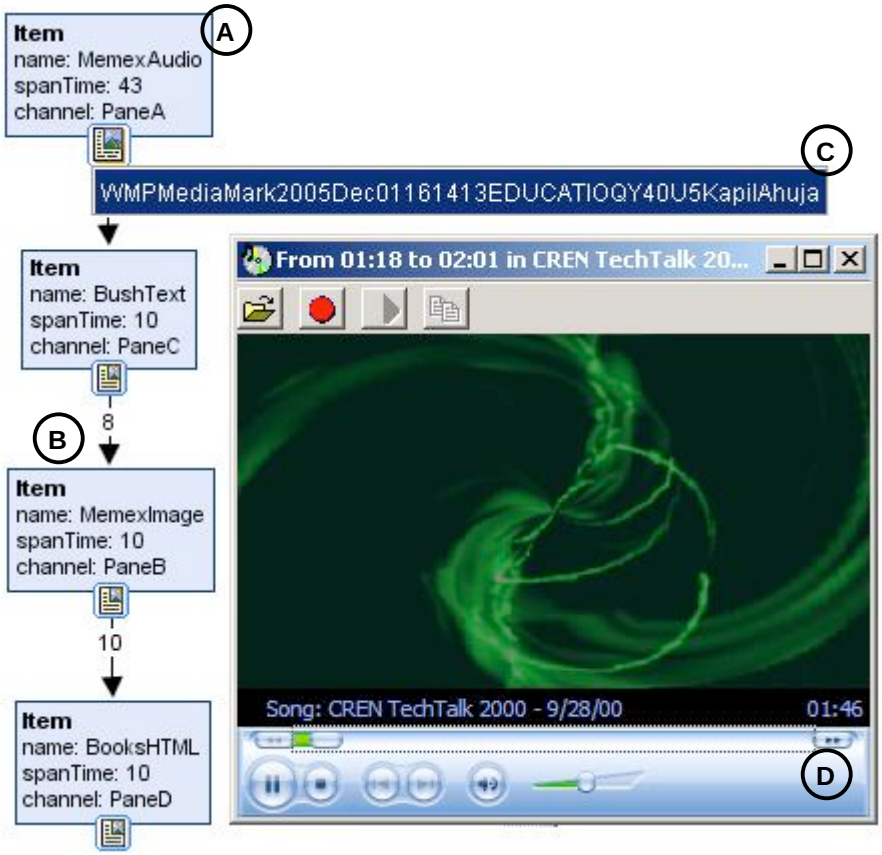

Figure 5. A CmapTools concept map representation of a SIMPEL presentation. A) Concepts represent items and are each associated with at least one mark; B) Ordering of items is represented by directed links. The linking phrases represent the relative time difference (in seconds) between the playing of two items; C) The highlighted mark points to an audio clip describing Vannevar Bush's memex; D) The audio clip playing in a media player (the complete audio file is a talk on digital libraries).

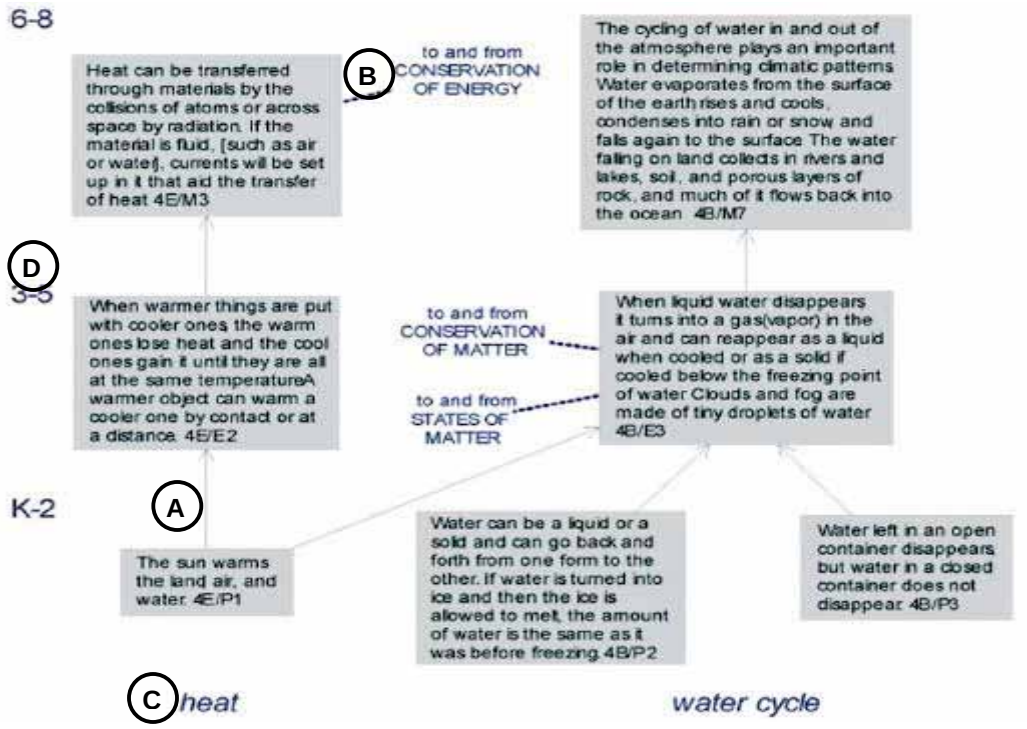

Figure 6. (Source: (Sumner, T., Ahmad, F. et al. 2005)) A section of a strand map called "*Weather and Climate*" – the full map consists of 22 benchmarks, 7 of which are shown here. A) The arrows indicate how one benchmark supports the ideas in the next benchmark. B) Dotted lines show connections to other maps (e.g., *Conservation of Energy*). C) Vertical strands are shown in the bottom of the map (e.g., heat and water cycle). D) Grade-levels are shown on the left (e.g., K-2, 3-5, etc)

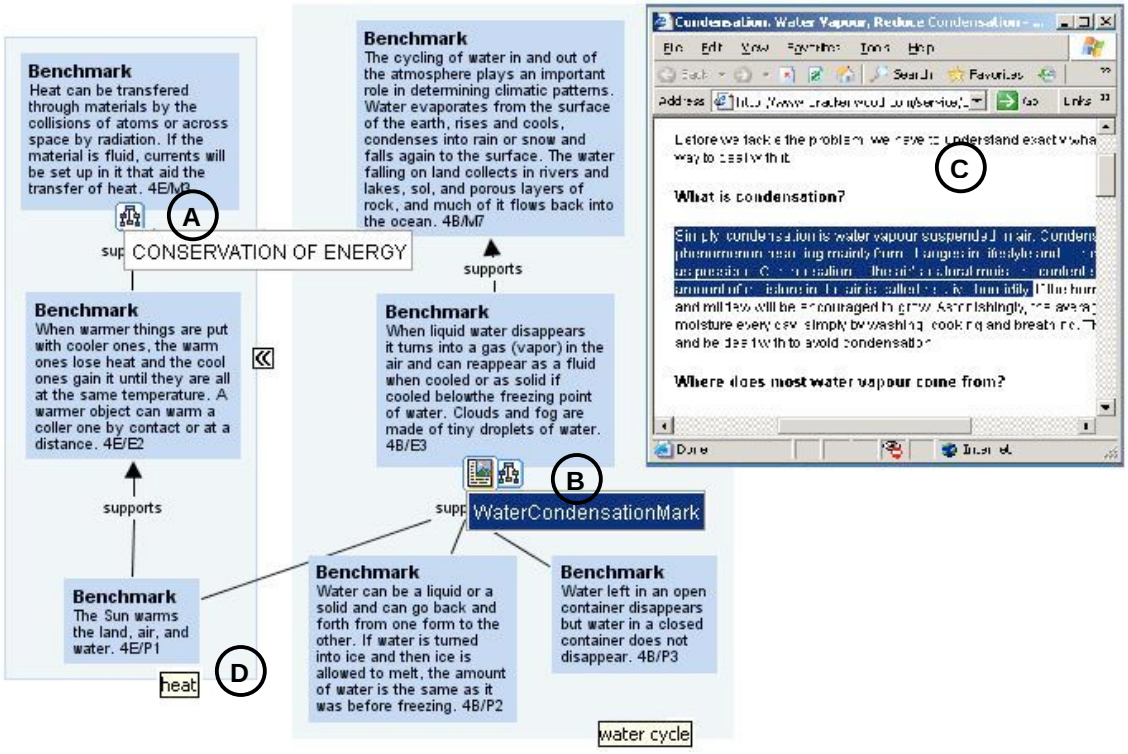

Figure 7. A CmapTools concept map representation of the "Weather and Climate" strand map shown in Figure 5. Benchmarks are represented by concepts, and links represent relationships between benchmarks. A) Connection to other strand maps; B) A condensation mark, attached as a resource to a benchmark; C) Activation of the condensation mark shows the selected information in its original context; D) Nested nodes and matching tooltips signify vertical strands in a strand map.

The Superimposed Multimedia Presentation Editor and Player (SIMPEL), is an SA that allows a user to reference information of many types (including text and multimedia content), at varying levels of granularity, and compose synchronized multimedia presentations from this information (Murthy, U., Ahuja, K. et al. 2006). For example, for a specific topic a user can select an audio clip, some images, and some text. She then can "play" (i.e., render in specific panes of a window) this information-set in some order. Figure 3 shows the XML representation of a SIMPEL presentation, describing Vannevar Bush's memex. Figure 4 shows a snapshot of SIMPEL's play interface, playing the same presentation.

In Figure 5, we show one way of using a CmapTools concept map to represent a SIMPEL presentation (emphasizing the structure of the superimposed document). The figure is a result of merging multiple snapshots of various actions on the concept map. A SIMPEL presentation consists of a time-ordered sequence of information items, where each item is associated with (at least) a mark and a channel (abstract output device to display the mark). In the CmapTools concept map representation of a SIMPEL presentation, a concept is used to describe an item. Channel information is included in the concept label. The mark attached as a resource to this concept represents the mark associated with the item (example, audio clip, image, or text selection). Directed links may be used to represent timing information and relative ordering of items. For example, the link between the BushText and MemexImage items means that MemexImage will be activated 8 seconds after BushText. The number 8 in the link may be considered as short hand for the phrase "plays 8 seconds before". This mapping enables representation of both sequential and parallel alignment of information items. Items beginning in parallel can be represented in multiple ways. For example, more than one mark resource could be attached to an item (represented by a concept). For more complex hypermedia-like presentations, the concept map could branch out into different options at a particular node, thus creating a hierarchical arrangement (where presentations may follow multiple paths).

3.2 Strand Maps

The Strand Map service enables users to build and navigate interactive visualizations of related learning goals, called *benchmarks*, and to request digital library resources aligned with benchmarks (Sumner, T., Ahmad, F. et al. 2005). Superimposed Strand Maps, an initiative by Portland State University, is aimed at exploring the use of superimposed information in an educational setting using a set of web-based tools for integrating strand maps into a curriculum (Delcambre, L. and Hanson, E. 2005). This will enable linking benchmarks to digital library resources at varying document granularities (e.g., linking a benchmark on database consistency to relevant chapters in an electronic book on database management systems). Figure 6 shows a section of a strand map, called "Weather and Climate". A strand map consists of node link representations illustrating a set of relationships between benchmarks organized around a topic. Each map contains vertical strands reflecting key ideas in that topic. Each strand is cross-referenced by grade levels.

Figure 7 shows one way of using a CmapTools concept map to represent the "Weather and Climate" strand map. The figure is a result of merging multiple snapshots of various actions on the concept map. Benchmarks are represented by concepts, and links represent relationships between benchmarks on a topic. Strands may be represented in multiple ways – by using color, by using one annotation for a set of concepts representing a strand, or by making use of a nested node (as shown in the figure). Grade levels can be represented in a similar manner, using color, annotations, or nested nodes (not shown in the figure). Each benchmark can have one or more marks associated with it, representing the digital library resource aligned with that benchmark.

4 Conclusion and Future Work

In this paper, we described how a concept mapping tool, IHMC CmapTools, may be enhanced below and above to facilitate representation and use of SI. We illustrated this by showing how concept maps in IHMC CmapTools may be used with two superimposed applications – SIMPEL and Strand Maps.

We believe that there are a number of benefits in this approach. Apart from providing more detailed information about a concept, a mark (to an information resource) may help in retrieving the original

information context of a particular concept. For example, a student may want to see the explanation of entities in the context of a paper that describes entity-relationship diagrams, and can use a mark accordingly. A key benefit in merging concept mapping and SI is that it will support the needs of two audiences: 1) the concept map user community – by providing a methodology to access resources at varying granularities, and 2) the SI user community – by giving them a new modeling tool to use and organize SI. A user would need to specify all marks (e.g., marked up regions, sub-document parts, anchors for hypermedia) only once, and add them as CmapTools resources, which later could be used by them or others (e.g., collaborators, students).

We are working on developing formal definitions of SI concepts. In doing so, we hope to be able to provide a common ground to study (among other things) SI, knowledge management (including concept map representations of knowledge), and annotations. We plan on further integration of SI functionality within CmapTools in order to treat marks as a separate resource type. This will enable access to the excerpt and context of the marked region from CmapTools (as is already available in another superimposed application called Sidepad (Murthy, S. 2005)). We also plan on conducting usability evaluations to validate and get feedback on the work described here.

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