COPLINK:
Visualization and Collaboration for Law Enforcement

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Abstract

1. Introduction

Funded by the National Institute of Justice and the National Science Foundation, the University of Arizona's Artificial Intelligence Lab has teamed with the Tucson Police Department (TPD) and the Phoenix Police Department (PPD) to develop the COPLINK application. The COPLINK project aims to develop knowledge management systems technologies and methodology that are appropriate for capturing, analyzing, visualizing, and sharing law enforcement related information in social and organizational contexts. The basis of such research is grounded in information retrieval, computational linguistics, information visualization, artificial intelligence, multimedia systems, multi-agent systems, and telecommunications. We also study the organizational, social, cultural and methodological impacts and changes organizations must implement to maximize and leverage on a law enforcement agency's investments in information and knowledge management. The academic foundation for such research is based on social informatics, decision theory, communication theory, cognitive psychology, and managerial and organizational research (Hauck & Chen, 1999). The focus of this paper is on the visualization and collaboration components of COPLINK. For more information on the COPLINK project, refer to: (Chen et al., 2002a and Hauck et al., 2002).

2. Visualization

To visualize law enforcement related data, we employ the hyperbolic tree, based on hyperbolic geometry (Coxeter, 1965), as well as the geo-mapping techniques described below. InXight (a spin-off from Xerox Parc) was first to use the hyperbolic tree for visualization of hierarchies (Lampings, 1995). It results in a fish-eye view of the tree where the angle of each sub-tree is equal to the angle of its parent, providing a convenient way to visualize exponentially growing trees (such as large hierarchies 0. This is an elegant way to see the big picture and the interesting details at the same time. When utilized to view relationships between different law enforcement entities (people, vehicle, location, organization), the user can search all entities having a relationship with a given search term (using the concept space technique (Chen & Ng, 1995, Hauck et al., 2002), and view these relationships in the form of a hyperbolic tree as well as in a hierarchical tree structure. This includes hidden associations not stored in the database, which have to be identified by domain experts. We have developed some customized features for the hyperbolic tree in COPLINK. The degree of the relationship is indicated by the thickness of arcs. Filters are used to avoid visualization clutter. They include a slider for the user to select the number of relationships to be displayed. A filter on entity type can selectively display specific

entity types only (person, organization, address, crime type or vehicle). Different colors distinguish between the various entity types. Our hyperbolic tree is a multi-level tree to display multi-levels of associations. We can also display additional information using the tool-tip on a node. The tree is built dynamically, based on user input rather than on pre- defined information. A hierarchical tree representing the same relationships is displayed alongside the hyperbolic tree. An example of using the hyperbolic tree in a COPLINK scenario, is illustrated in figure 1.

We use geo-mapping to view locations of incidents on a map of the city of Tucson. This helps to visually identify incident locations. Law enforcement personnel will be able to search cases based on selected areas and to identify spatial relationships among crimes. This might assist them in discovering crime trends and patterns, and to identify "hot spots" of crime. Most law enforcement agencies employ a variety of geo-mapping tool as a separate entity. The strength of our geo-mapping application comes from the fact that it is integrated with all COPLINK features. In designing the geo-mapping component of COPLINK, some of our design goals have been: ease of integration with COPLINK, browser compatibility (IE 5 and up), ease of use and scalability. We are using ArcIMS from ESRI, to display a map of the city of Tucson and locate various incident types on the map. The user can zoom in and out on the map depending on whether a more detailed view is desired. Starting with the incident types shown on the map, the user can select an incident and view the case details related to that incident. An example scenario is shown in figure 2.

3. Collaboration

In law enforcement, as in many other application areas, collaboration among members of dynamically-defined, task-oriented teams plays an important role in everyday operations. As part of our ongoing COPLINK system development and research effort, we are developing supporting technology and infrastructure, implemented in the COPLINK Agent system, to enable a limited set of law enforcement collaboration activities. We are also exploring resulting technology adoption issues from both the user and organizational perspectives.

Specific challenges motivating the development of COPLINK Agent are: (a) pressing real-time or near real-time requirements for information available from distributed data sources that change dynamically; (b) different levels of information sharing needs among law enforcement officers (e.g., sharing of results of information search, sharing of information search strategies, sharing of metadata such as who have performed similar searches in the past); (c) intuitive user interface and user information search history and session management; (d) real-time alerting through cell phone and pager if certain specified changes have occurred in the data sources; and (e) balance between sharing and security measures and privacy protection. Literature on data warehousing e.g., (Chen et al., 2002b), agent-based personalization e.g., (Maes, 1994), collaborative information management e.g., (Goldberg et al., 1992, Sarwar et al., 1998) has been directly related to the development of COPLINK Agent. COPLINK Agent is implemented as a three-tier Web application. The user accesses the system through a Web browser. The interface layer of the system is coded through JSP and HTML. Access to backend data is enabled through JDBC connection. To ensure maximum system configurability and extensibility, all business logic has been coded as JavaBeans.

We briefly describe the functionalities of the main components of COPLINK Agent below. The Login Module manages user login information and associates each user with her own profile, stored in a centrally managed collaboration database. Through the Search Module, the user can query the underlying data sources via search screens tailored for each source. The user can perform sophisticated one-shot queries such as person, vehicle, and location searches as one

would on COPLINK Connect. When COPLINK Connect returns search results, a search session would be treated as completed. In COPLINK Agent, however, the initial research results become stepping stones for further actions related to monitoring and collaboration. The user can select a set of returned records and request ongoing monitoring: when any changes occur to these records, the user will be notified through a set of pre-specified methods. The user can also request to be notified when any new records meeting the search criteria are added to the system. In addition, the user can request the list of other users who have either input the same search criteria or have searched or monitored the records of interest in the past. Furthermore, the user can elect to be notified when such scenarios take place in the future. The Collaboration Module functions at the backend and enables collaboration among the users. In the current implementation, a simple form of collaboration, i.e., identification of the users searched or searching for similar information as discussed above, is supported.

An important aspect of collaboration is to promote effective sharing among the users while protecting user privacy. COPLINK Agent provides two types of privacy control mechanisms. The first is to allow the user to choose whether the information search sessions may be viewed by other users; the second is whether the user herself will receive notifications when other users (assuming they have indicated that other users can view their information searches) perform similar searches. More fine-grained control is also possible in the current system. For instance, a user might prefer to receive notifications of similar searches being performed by users in the same unit but not other users. The Monitoring Module is another backend module that automatically and periodically monitors (queries) the database for any user-specified changes and alerts the interested officers through the Alert Module. The Alert Module brings information to the interested parties through customizable alert methods. It "pushes" information to the user when desired. The types of information the Alert Module currently delivers are: (a) notifications from the Collaboration Module indicating who are performing similar searches, and (b) change alert messages output by the Monitor Module. The currently implemented set of alerting methods includes: Web-based messaging available on the COPLINK Agent main GUI, e-mail, short text messages on cell phones, and alphanumeric messages on pagers.

The COPLINK Agent system has been developed in the context of our COPLINK research effort in the past year. It is fully implemented and we are in the process of deploying a demo version of COPLINK Agent in the TPD and conducting a small-scale user evaluation study. Currently through COPLINK Agent, the users can access information from COPLINK database DB, which has close to 2 million records, Web-based Tucson City Court, and offer-line TPD Dispatch System (data is delayed for one day). Access to other data sources such as the Arizona State Motor Vehicle Department databases and probation databases are also being planned for the near future. We are currently actively pursuing the following research directions.

COPLINK is currently being deployed at the Tucson Police Department. A prototype is also being developed for the Phoenix Police Department. The enhancements in the areas of visualization and collaboration described here, will be integrated with COPLINK and deployed in the near future.

One important area of future study is to enable "intelligent" collaboration among the law enforcement officers. The current COPLINK Agent system relies on exact, purely syntactical matching in data records or queries to identify the set of users performing similar searches. Fuzzier, less restrictive forms of matching are desired in the law enforcement application. For example, a police officer might want to be notified when an associate of a known suspect is being arrested even if in previous search sessions he only specified monitoring requests for this suspect but not explicitly for his associates. We hypothesize that in large organizations, the collaboration

module will generate numerous notifications which could cause user information and cognitive overload. Research is planned to develop intelligent filtering mechanisms to deal with issues in a task-dependent, context-sensitive manner. We are also planning to extend the system so that the user can access the full functionality of the system through mobile devices such as PDA and cell phones, as opposed to simply receiving notifications on these devices. Hand-held device markup and wireless markup standards will be leveraged in this research. We have done several user studies at TPD to gain understanding of the usefulness of COPLINK for the users (Hauck et al., 1999). We plan to extend these user studies to the new collaboration and visualization components of COPLINK.

FIGURES

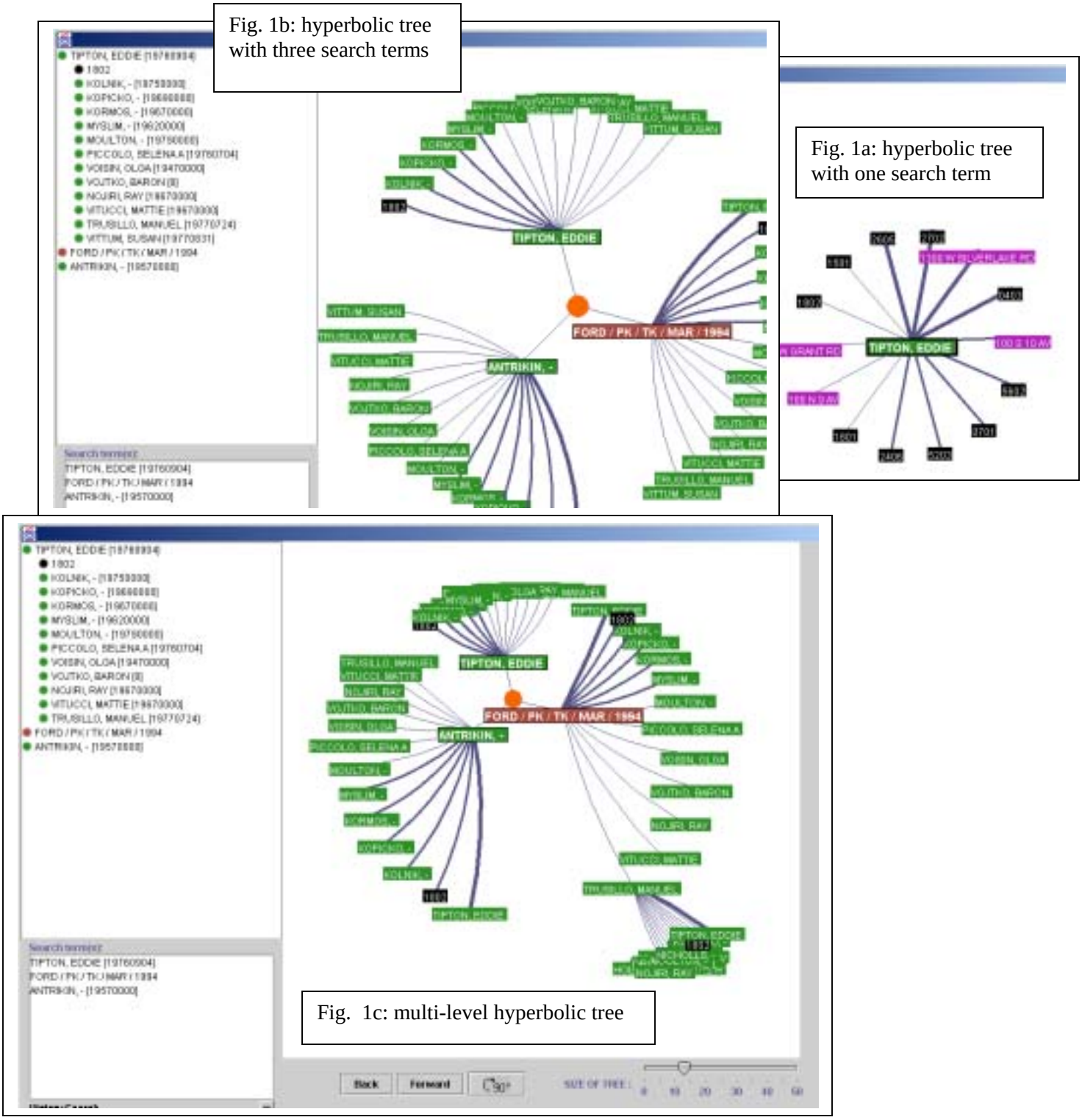

Fig. 1b: hyperbolic tree with three search terms

Fig. 1a: hyperbolic tree with one search term

Fig. 1c: multi-level hyperbolic tree

Figure 1: Hyperbolic Tree view of associations in COPLINK
An officer searches for all entities related to a suspect, Eddie Tipton. All entities related to this suspect are displayed (fig. 1a). The thickness of the arcs indicates the weight (closeness) of the relationship. The color indicates the entity type (green: person, pink: address, brown: vehicle, black: crime type, blue: organization), displayed at the bottom of fig. 1c.
Suspect was seen driving a 1994 Ford truck 1994. A witness thinks this suspect knows a person whose last name is "Antrikin". These two terms are entered as search terms; terms may also be selected from the hyperbolic tree using the mouse. Fig. 1b displays all entities associated with each search term. Another suspect's name (Trusillo Manuel) appears as one of the relationships. By selecting that entity, the tree expands an additional level (fig. 1c) and displays all entities related to it.
The officer may choose to view the hyperbolic tree using filters listed at the bottom of fig. 1c. These include different entity types as well as a slider that limits results to a given number. (In fig. 1c the officer has used the slider to view the top 15 results according to the weight of the relationships). The officer can better view one section of the tree by moving it to the center.

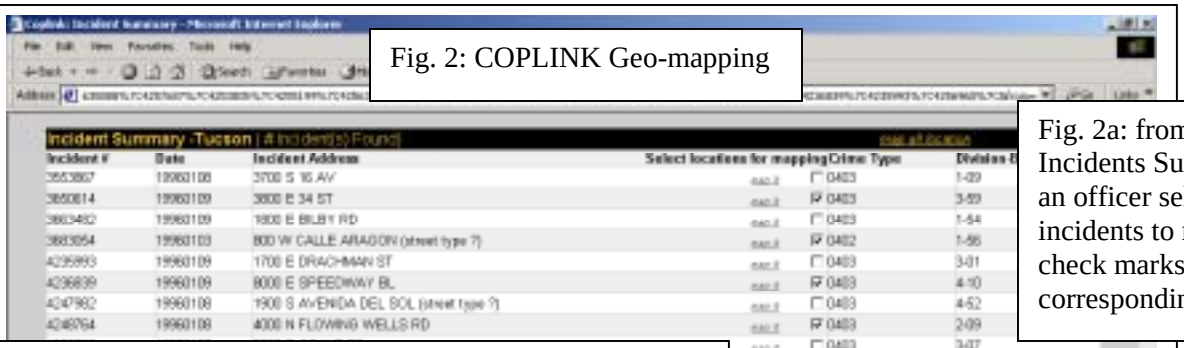

Fig. 2: COPLINK Geo-mapping

Fig. 2a: from COPLINK Incidents Summary table, an officer selects 4 incidents to map: see check marks in corresponding boxes

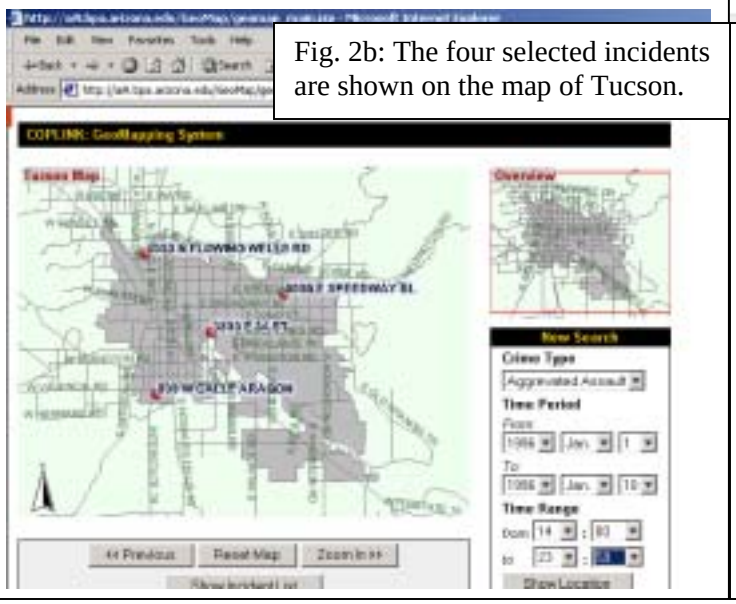

Fig. 2b: The four selected incidents are shown on the map of Tucson.

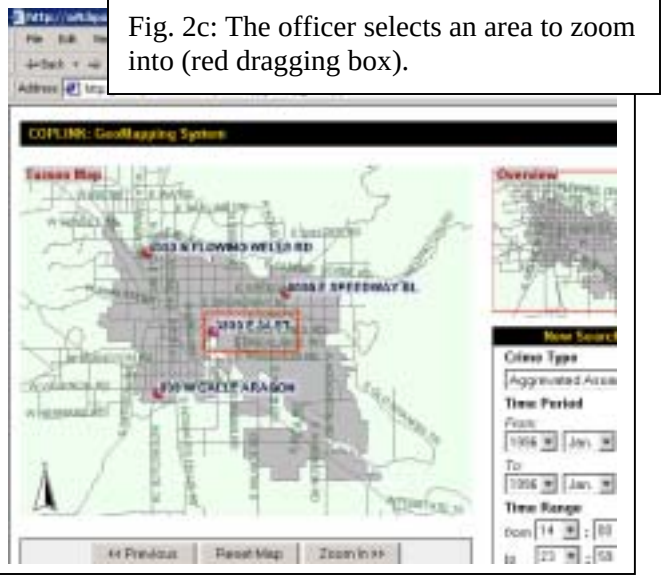

Fig. 2c: The officer selects an area to zoom into (red dragging box).

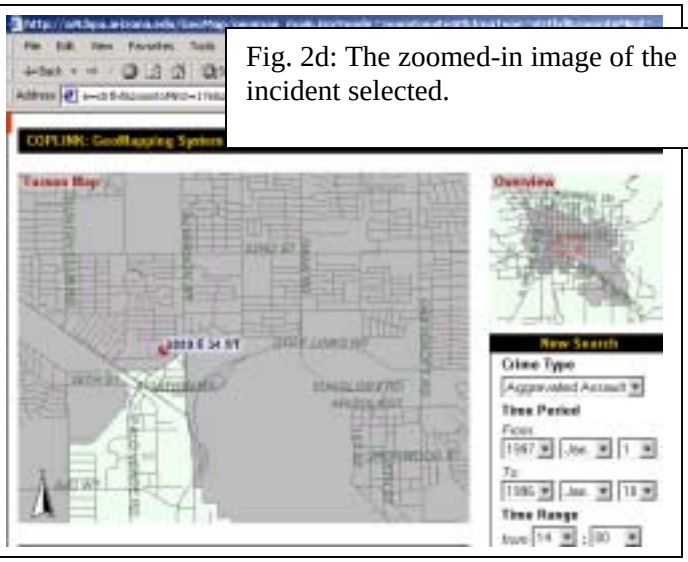

Fig. 2d: The zoomed-in image of the incident selected.

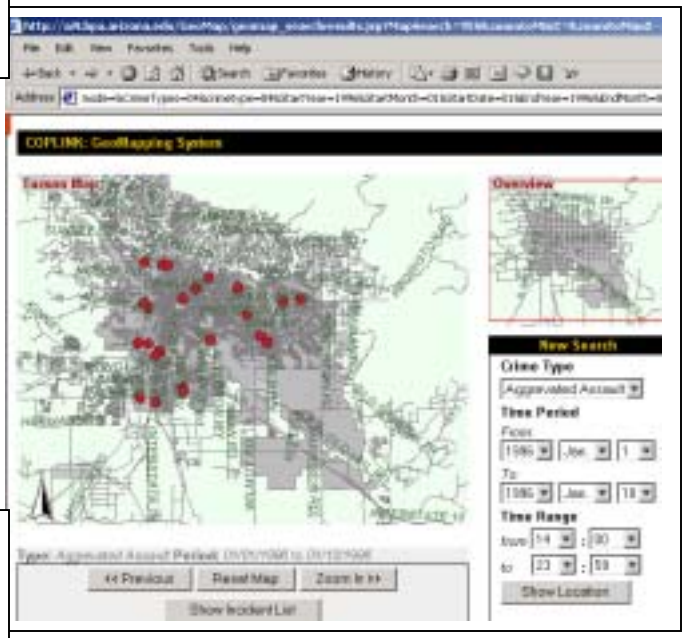

Fig. 2e: This illustrates another use of geo-mapping. The officer does not start with the incidents summary table from COPLINK but directly inputs information such as crime type (aggravated assault), dates (Jan. 1, 96- Jan. 10, 96) and time range (2 PM till midnight). View is all incidents on the map of Tucson, corresponding to this information.

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