Coplink: A Case of Intelligent Analysis and Knowledge Management

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Abstract

Law enforcement agencies across the United States have begun to focus on innovative knowledge management technologies to aid in the analysis of criminal information. The use of such technologies can serve as intelligence tools to combat criminal activity by aiding in case investigation or even by predicting criminal activity. Funded by the National Institute of Justice, the University of Arizona's Artificial Intelligence Lab has teamed with the Tucson Police Department (TPD) to develop the Coplink Concept Space application, which serves to uncover relationships between different types of information currently existing in TPD's records management system. A small-scale field study involving real law enforcement personnel indicates that the use of Coplink Concept Space can reduce the time spent on the investigative task of linking criminal information as well as provide strong arguments for expanded development of similar knowledge management systems in support of law enforcement.

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1 Introduction

The development of information technologies during the past few years has enabled many organizations to improve both the understanding and the dissemination of information. The development of powerful databases allows information to be organized in a manner that improves access to it, increases speed of retrieval, and expands searching flexibility. Furthermore, the Internet now provides a vehicle for the sharing of information across geographical distance that encourages collaboration between people and organizations.

Law enforcement agencies across the United States have begun to adopt innovative knowledge management technologies to aid in the management of criminal information. Such technologies can serve as intelligence tools to combat criminal activity by aiding in case investigation or even predicting criminal activity. In this research project we developed and evaluated one such knowledge management tool in the context of real-life criminal investigation by real law enforcers, fully acknowledging that many issues as well as obstacles must be addressed to ensure the successful deployment of this and similar information technologies.

1.1 Law Enforcement Technology Problems

Several issues combine to play a part in the utilization of information tools in law enforcement agencies.

1.1.1 Access to Information

Although much information exists, law enforcers often find it difficult to retrieve information from its sources. Because time can be a crucial factor in the completion of an investigation, ready access to information is critical. Obstacles to acquiring information in a timely manner can include restricted access to some systems for certain types of officers, or even long wait times for query returns. Although a detective may require information acquisition within 3-40 hours in real time, he or she may actually have to wait a few weeks to a month to receive data. Similarly, at many agencies, secure remote access to textual and multimedia databases is not currently available (Tucson Police Department, 1997a).

1.1.2 Interface

One important aspect of information technology for law enforcement is its ability to be used at the different levels within an organization. For example, support is needed for quick, street-level problems as well as for in-depth, lengthy investigations (Lingerfelt 1997). Given a vast range of functional needs and user abilities, an area of importance is the design of the interface. Although some departments are turning to use of graphical user interfaces, many local law enforcement agencies use text-based, front-end interfaces with their current database systems.. Navigation through these systems is often difficult and the users find the system commands counterintuitive. Despite the presence of much useful functionality, it seems that very few users are able actually to operate the

functions. And because many interfaces are restricted to textual information, multimedia information such as mug shots and video clips cannot be incorporated and accessed.

1.1.3 Knowledge Management

The general area of knowledge management (KM) has attracted an enormous amount of attention in recent years. Although it has been variously defined, it is evident that knowledge management exists at the enterprise level (see (Davenport and Prusak 1998) and is quite distinct from mere information (e.g. see (Nonaka 1994; Davenport and Prusak 1998; Teece 1998)). Also apparent in this area are the challenges that knowledge management poses to an organization. In addition to being difficult to manage, knowledge traditionally has been stored on paper or in the minds of people (Davenport 1995; O'Leary 1998). The KM problems facing many firms stem from barriers to access and utilization resulting from the content and format of information (Jones and Jordan 1998; Rouse, Thomas et al. 1998). These problems make knowledge management acquisition and interpretation a complex and daunting process. Nevertheless, knowledge management information technologies have been developed for a number of different applications, such as virtual enterprising (see e.g., (Chen, Liao et al. 1998)), joint ventures (see e.g., (Inkpen and Dinur 1998)), and aerospace engineering (see e.g., (Jones and Jordan 1998)).

The same problems of knowledge management exist at the specialized organizations of law enforcement. Many record management systems for law enforcement agencies contain a large amount of data for each case or incident, but although data may be available, they are not available in a form that makes them useful for higher level processing. For example, the ideal knowledge management system should be able to provide information about problems that have not been identified previously, and thus be able to give innovative and creative support for new investigations. The conversion of information to knowledge is an important concern for law enforcement agencies. Information is a product that is designed with a purpose in mind, while data serve as the ingredients in this product (Sparrow 1991). Furthermore, addressing the conversion of information to useful and easily understandable knowledge is a powerful aspect of knowledge management that has thus far been missing from most law enforcement information systems.

1.2 TPD IT Problem and Direction

The Tucson Police Department (TPD) recently evaluated the status of its information technology. Having concluded that all the problems mentioned currently exist in the organization, the department agreed to participate in research to investigate the potential of current state-of-the-art, near-term, and cost-effective database, Intranet, and multimedia technologies to make computer justice information database integration, management, and access more effective (Tucson Police Department, 1997b). Although the scope of this project includes a multilevel development plan on different information technologies, the focus of the research reported here is on the improvement of criminal

incident information retrieval. The first step in this process was the evaluation of TPD's current Records Management System (RMS).

1.3 TPD's Records Management System (RMS)

The main database at TPD is the Records Management System (RMS), which stores a wide variety of data, including criminal case information and incident information from calls for service recorded from the Department's Computer-Aided Dispatch (CAD) system. RMS is a text-based system that is accessed using VAX terminals stationed in many offices in the main headquarters as well as at many substations located around the city.

Similarly to systems described previously, RMS has many problems pertaining to its interface, access to information and lack of knowledge management. Although users are able to search on name queries, location queries, vehicle queries, etc., they are not able to search for multiple types of fields at one time. In addition, users of RMS complain that, depending on the type of query, RMS can take from a few minutes to a few hours to return its results.

1.4 Current TPD Knowledge Management Practice

A basic task for detectives and crime analysts at TPD is to create knowledge from information. In this case, information is made up of approximately 1.5 million criminal case reports, containing details from criminal events dating back to 1986. Tacit knowledge has also been described as the means through which new knowledge is generated (Nonaka and Takeuchi 1995) as well as the practical knowledge used to perform a task (Polanyi 1962). It is tacit knowledge that is used as investigators try to tie together information to solve cases and crimes. This ability to combine information to create knowledge is often hampered by the amount of information that exists.

The purpose of this paper is to explore the development of a knowledge management system that can provide the functionality of intelligence analysis that currently do not exist in the RMS system. This system is designed to serve as a type of knowledge tool that works towards the same purpose as current tacit knowledge practices of crime analysts and detectives and has been evaluated in a real life context. Its findings also are discussed.

2 Literature Review: Use of IT and AI in Law Enforcement

A number of applications that take advantage of various information technologies for law enforcement purposes currently exist. As the number of agencies that utilize these types of technologies is growing, the development of useful artificial intelligence tools continues to progress. And because there are many uses of databases, intelligence

analysis and other technologies, the potential uses for these types of technologies have yet to be fully explored.

2.1 *Database Technologies*

Database technology plays an important role in the management of information for a police department. Previous research has detailed the use of database technology to allow for the organization of information in a form that can be easily searched by officers and other employees in a police department (Lewis 1993; Hoogeveen and van der Meer 1994; Miller 1996; Lingerfelt 1997; Schellenberg 1997; Wilcox 1997). The use of relational database systems for crime-specific cases such as gang-related incidents, and serious crimes, such as homicide, aggravated assault, and sexual crimes, has proved to be highly effective (Fazlollahi and Gordon 1993; Pliant 1996; Wilcox 1997). The use of databases in these criminal areas is often targeted because it allows for a manageable amount of information to be entered into the database and, in addition, can combine information that may normally exist in neighboring police districts.

2.2 *Intelligence Analysis for Criminal Data*

Solving problems by analyzing and generalizing current criminal records is a function of the daily routine of many crime analysts and detectives. The amount of information that these investigators must analyze is often overwhelming, a phenomenon often referred to as "information overload" (Blair 1985). Potent intelligence tools can be useful in the analysis of available criminal records and aid in the investigation of current cases by alleviating the crime analysts' information overload and reducing information search time.

There are currently a number of systems that serve as intelligence analysis tools for law enforcement. Many technologies use neural networks to solve problems by developing associations between information objects and being trained to solve problems by comparing known objects with unknown objects. Some applications utilize visualization and time analysis to examine information. For example, the Timeline Analysis System (TAS) can help analysts visually examine large amounts of information by illustrating cause-and-effect relationships. This system graphically depicts relationships found in the data, resulting in trends or patterns (Pliant 1996). Expert systems that employ rule-based information have also been developed to assist in knowledge-intensive activities (Bowen 1994; Brahan 1998). These systems attempt to aid in information retrieval by drawing upon human heuristics or rules and procedures to investigate tasks.

3 Approach

The University of Arizona has refined an intelligence analysis technique to help improve the organization and categorization of information, resulting in the reduction of user information overload and therefore in more efficient searching. This knowledge

management approach strives to use information to create underlying connections and relationships that can lead to the generation of new knowledge. This technique is based on an automatically generated thesaurus or concept space.

3.1 *Concept Space for Intelligence Analysis*

The concept space algorithm automatically computes the strength of relationships between each possible pair of concept descriptors identified in a document collection. It is important to note that this concept is not a novel technique. For example, the use of similarity functions and ranking procedures for information retrieval was found to be both effective and efficient (Noreault, Koll et al. 1977). For a more extensive review of our variation of this algorithm, see (Chen and Lynch 1992; Chen, Schatz et al. 1995; and Chen and Ng 1995). What makes this research different from previous work, is that we have refined and applied the concept space to the specific data set and the information retrieval application to law enforcement. The process of creating the concept space for the Coplink application can be summarized as follows.

- *Document collection*
  A collection of 1.5 million criminal-case reports from the current TPD records management system that span a time frame from 1990 to August 1997constituted the document records in this analysis. From previous user requirement analysis, six information fields from the database were deemed relevant for co-occurrence analysis.

- *Co-occurrence analysis*
  Co-occurrence analysis, a basic technique dating back to the 1960s (see e.g., (Van Rijsbergen 1977)), creates a concept space that is a graph of concepts. In addition, co-occurrence analysis uses similarity and clustering functions (Chen & Lynch, 1992) to weight relationships between all possible pairs of concepts. This net-like concept space holds all possible associations between objects, which means that all existing links between every pair of concepts is retained and ranked.

- *Associative retrieval*
  When a search term is entered into the Concept Space user interface, the system returns a list of co-occurred terms for user analysis. In the Coplink Concept Space, the associated terms are presented using multiple rank-ordered lists in a tabular format. The six tabular columns represent the six information fields used in the co-occurrence analysis. The use of a tabular format creates better summarization and visualization of the retrieved information by allowing officers to target the information field/type that they want.

3.2 *System and Interface*

In the application of concept space to the collection of TPD case records, a number of modifications were employed. Table 1 provides more detail on the concept space data analysis. An important modification was the identification of certain fields for analysis.

This included both fields that can be used as search terms and fields that are returned by the system. The relationships between search terms are an important issue not focused upon in prior concept space applications. For an investigator, relationships between objects must not only be identified, but for crime analysis must also be explicitly understood. The format of the query is consequently yet another consideration. Officers may use the Coplink Concept Space in search for particular relationships, so their being able to request a specific output format is a valuable component of this application for law enforcement personnel.

Size of Database	1.5 M criminal records (528 MBytes)
Size of Resulting Concept Space	1.24M terms (478 MBytes)
Number of Names	644,143 terms
Number of Addresses	210,003 terms
Number of Vehicles	361,126 terms
Number of Organizations	27,158 terms
Number of Weapons	96 terms
Number of Crime Types	719 terms
Processing Machine	DEC Alpha Server 4100
Processing Time	24 minutes

Table 1: Details on concept space analysis

3.2.1 Field Identification

In criminal investigations, an officer can acquire information leads that fall into a number of different categories and work together to create the 'story' that describes the crime. In the categorization of case reports, we chose to break down the search terms into six search objects: person, address, organization/business, vehicle, crime type and weapon. These objects contain information that is currently being stored in fields of the records management system at TPD. A user can choose to enter up to four objects in any combination to begin a search.

The different objects contain specific elemental data. For example, the name object contains last name, first name, and middle initial. The majority of addresses use a street number, street name, street type (e.g., Rd, St, Av), and apartment number. The crime type identifies the type of crime committed in accordance to the standard FBI classification system that is used in the United States. Vehicle information contains a number of possible fields, including the make, model, type, year, color, and license plate number. Users are able to search on any combination of these elements and across different fields. By employing different search objects, officers are able to easily search by the specific type of information that he/she has available.

3.2.2 Relationship Identification

The purpose of this search tool is to discover relationships between the different search terms or objects. It is not only important to know that there is a relationship, but it is also important to know what the relationship between objects is. Figures 1-3 illustrate a

sample scenario using the concept space tool, which provides a detailed description of how relationships can be identified, given that the officer has a limited amount of information[1].

Scenario: Robbery at a local convenience store. Night store clerk only remembers that the suspect drove away in a white pickup truck.

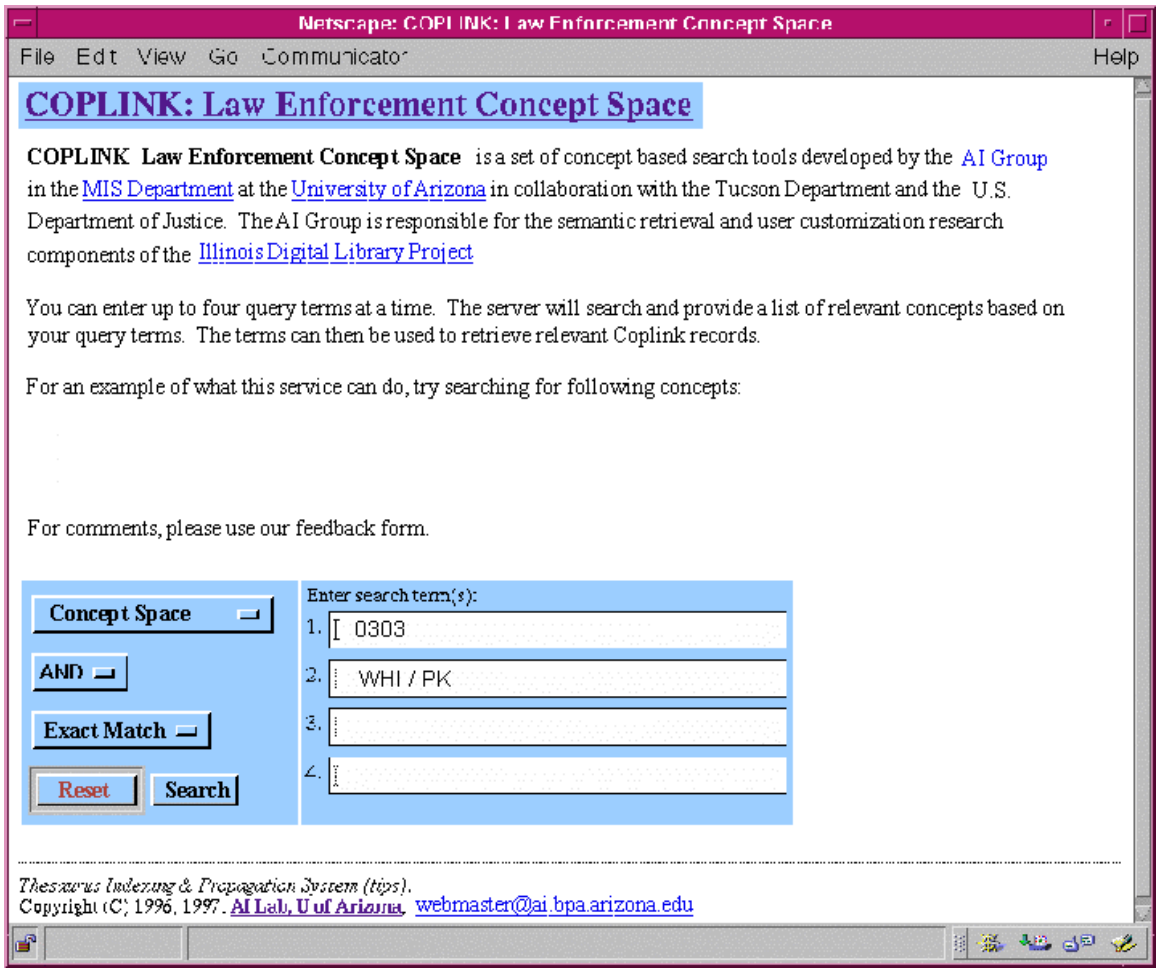

Figure 1: Coplink Concept Space Input Screen

Using Coplink Concept Space, officers are able to input any type of information object as a search term. For our scenario, the investigator can generate a lead given the type of crime and the use of a white pickup truck. This figure shows the input screen in which the investigator has entered the crime type 0303 (robbery of a service station) and white pickup truck.

[1] Due to its sensitive nature, the actual information shown in these scenarios has been altered.

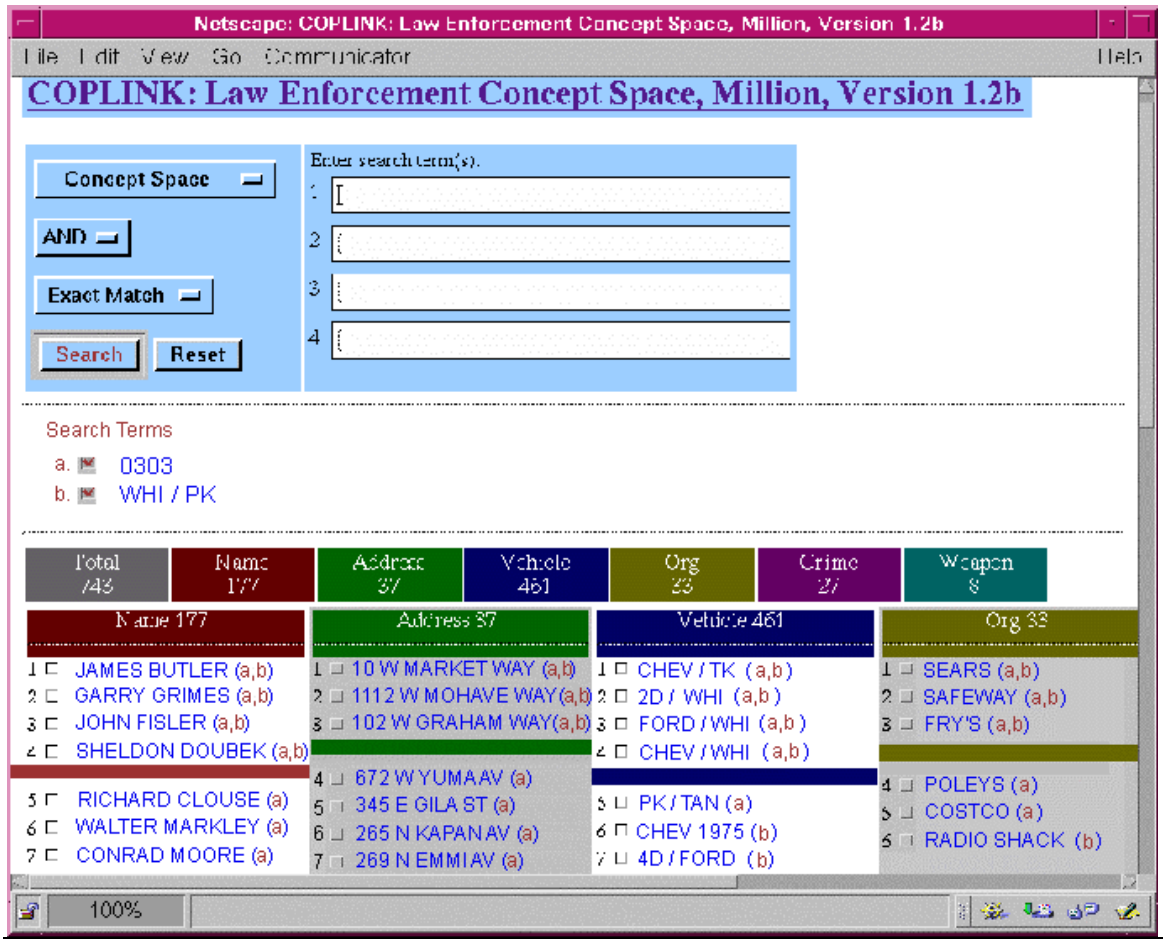

Figure 2: Concept Space View

After entering the two pieces of information, the Concept Space for the query is returned. Note that the Concept Space returns elements for each of the six information object types. Under the person type, the concept space has determined that there are entries that are associated with the crime type as well as the vehicle type. The resulting output contains lists for each of the search objects, all of which are somehow associated with the search terms entered by the user. In the output screen, the interface is designed such that each entry returned refers to the input object(s) with which it is associated. In addition, for queries that use multiple entries, the return entries for each object type that are associated with the greatest number of input search terms are those above the colored bar. The corresponding letter(s) in parentheses after each output term indicate the exact search object that was found to be associated with each output term. This allows the officer to understand how the output terms are related to each of the search terms entered.

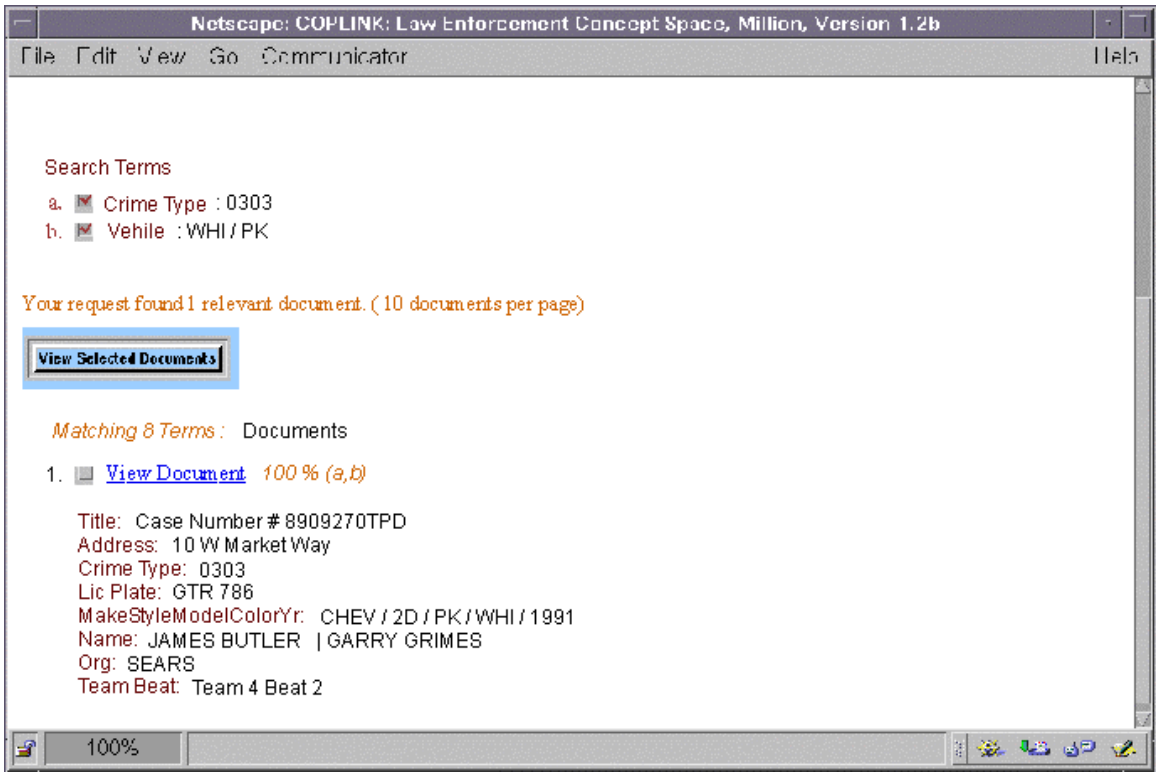

Figure 3: Detailed Document View

Wanting to know more about this similar past case, the investigator chooses to view more detailed documents about the prior crime that are associated with the entered information. These documents contain the specific case number information, all persons involved in the case, the crime type, the location of the incident, vehicles involved, and weapons information.

4 Research Design

In order to evaluate the usefulness and the usability of the concept space in a law enforcement setting, we conducted a study to determine the feasibility of this intelligence analysis tool in real life criminal investigations.

4.1 *Research Strategy: Field Experiment*

The use of the field experiment research strategy allows researchers to engage in investigative activities that can uncover key issues that cannot be acquired in the unrealistic confines of a laboratory. The Coplink Concept Space (CS) lends itself to this method of inquiry in many different ways. The use of Coplink CS is environment dependent. In order to be able to increase the external validity of the findings, we need to be able to evaluate the system in real-life situations. Also, given the actual application of this tool in doing their jobs, we wanted to give the officers the ability to test the application's functionality on current tasks and cases. Finally in dealing with the law enforcement field, we were confronted with an environment where we were unable to

command total control while demonstrating the value of the technology by aiding in the investigation of authentic police cases.

4.2 Experimental Design

The purpose of this research was to understand the effects that Coplink CS can have in law enforcement investigation and work practices. The interesting research questions that served as the focus for this study were:

> *RQ1: Can Coplink CS lead to increased productivity?* One hypothesis was that Coplink CS has potential to increase productivity by decreasing the amount of time required per search session. Each participant was asked to do at least one direct comparison between RMS and Coplink CS; qualitative data analysis collected from the journals and interviews was used compare the amount of time spent on each system.
> *RQ2: How is Coplink CS useful?* One goal of this study was to undercover the area or tasks in which Coplink CS, as a previously unavailable knowledge management tool, would be useful as well as tasks for which Coplink CS was not useful.
> *RQ3: Where should we focus our efforts for future development of Coplink CS?* As a user-centered design effort, it is necessary that we continuously draw upon user evaluation to guide future endeavors. By taking into consideration feedback from the subjects, we hoped to establish and prioritize the course of action for continuing development of Coplink CS.

- *Subjects*
  For this study, the specific group from TPD targeted to participate was made up of crime analysts, who investigate high-profile cases as well as create statistical reports on criminal activities. The analysts are the department's most technology savvy user group and are accustomed to using a number of different data sources. Eleven crime analysts and one homicide detective from TPD were asked to participate in the study. The detective was also experienced in using a number of different technologies.

- *Data collection method*
  The data collection methods employed in this study included documentation, interviews, and direct observation by both the researcher and a TPD officer working on the Coplink project. Documentation consisted of journals kept by each subject detailing actual search experiences. In-depth, structured interviews and direct observations were utilized in one pretest and at multiple posttest sessions. Due to the difficulty of recording actual times of searches, participants' reported time spent per search was used in comparing times spent addressing RQ1 for both the Coplink CS and the RMS systems. In addition, qualitative data analysis was focused on thematic or pattern matching of findings and anecdotal data (RQ2 and RQ3).

- *Experimental Procedures*
  A longitudinal design was used to evaluate the Coplink Concept Space application. Prior to exposure to Coplink CS, initial background structured interviews were conducted with the participants. For one week after this session, participants were asked to keep a journal documenting their search experiences on their current records management system. At the conclusion of this week, participants underwent a brief demonstration of the Coplink Concept Space and a training session in its use, after which they were asked to briefly evaluate the functionality of the system as well as how it compared with their current records management system. After the participants were shown the basic functionality of the application and were able to work through a number of trials, they were asked to use Coplink CS for a four-week period. During this time period, participants were again asked to complete journal entries on searches that they conducted using Coplink CS, after which we concluded the study with final in-depth interviews.

5 Results

The results of the TPD Concept Space study are quite supportive of its use in investigative law enforcement as a knowledge management application. In addition, results also uncovered a number of important issues that need to be addressed in future development efforts. Participants' logs of usage show that Coplink CS was utilized in 37 queries (732 minutes). A majority of the participants' feedback can be categorized into one of two general areas, task analysis and interface analysis. From a content analysis of journal logs and interview data, we were able to address each of the research questions underlying this study.

5.1 *Task Analysis*

From the journals and interviews, we were able to build a taxonomy of task types in which participants were engaged while using the Coplink Concept Space. Specifically addressing RQ2, the evaluation of tasks allows us to understand the strengths of Coplink Concept Space and the particular tasks that leverage those strengths.

5.1.1 Link analysis

Participants indicated that Concept Space serves as a powerful tool for acquiring information and mentioned its ability to determine the links between people, places, vehicles and other object types as invaluable in investigating a case. The impact of such link analysis upon investigative tasks is crucial to the building of cases. Assigned to investigate a crime, an officer can only hope to get enough information to provide a lead with which he/she can begin working. Too many cases have to be closed due to the lack of information or inability to tie together information data existing elsewhere in the records management system. Concept Space manages all the data in the records system in such a way that it can be used as knowledge that tells a story about the suspect. Link analysis can be described as being one of three types: directly linking known information, indirectly linking known information, and linking unknown information.

- *Directly linking known information*
  Objects that appear together in at least one case record characterize a direct link. One type of link analysis performed by participants dealt with establishing a direct relationship between two known objects.

- *Indirectly linking known information*

  An indirect link is a complex link between objects that exist in a number of incidents. Another way to perform a search is to enter two known objects and look at the concept space to determine whether any other objects relate to both of them. Although this is a more complex search, it allows the user to link objects indirectly. These objects are connected, but not within a single case report. This transitive relationship between objects is a powerful one for criminal analysis, because it allows officers to infer connections although explicit data connecting the objects may not exist in the current collection of case records.

- *Linking unknown information*

  One important way in which Concept Space can assist in acquiring leads is by allowing officers to browse through information and establish relevant associations even though these links were previously unknown to the officer. Given that an officer has some initial search terms, the Coplink Concept Space returns a number of possible associated terms. The officer can then add any of the resulting terms to the search to browse for possible relationships between them. This browsing technique allows an officer to perform analytical queries on possible connections to establish a lead.

The creation of links and leads for police officers is the creation of knowledge from a set of information (i.e., case reports). The knowledge generated begins to connect actors, locations, and objects in potential criminal activities. This knowledge management activity allows for the possibility of branching information seeking activities in different directions. Although this process can be conducted manually, it is quite difficult for investigators to create indirect links, especially given the amount of information that exists.

5.1.2 Summarization Analysis

Participants in this study also utilized the Coplink Concept Space application to quickly establish a brief summary of a particular object. Analysts would often enter an object and use tabular layout of information to quickly peruse the known entries for the subject. Because the output of the Concept Space spans all the cases in which a subject is involved, analysts can escape the boundaries of searching within a case and can instead search all existing cases that involve a particular subject.

5.2 *Interface Analysis*

In the development of an interface, it was our goal to design Coplink CS in an intuitive manner that fosters interaction. In general, users felt that the web-based interface of the Coplink Concept Space was engaging and quite easy to use. The use of color to delineate the different object types and the use of browser navigation tools provided the officers with a more intuitive interface than the text-based RMS system. Additionally, the ability to have results returned as either the concept space or brief/detailed documents allows users to specify the type of information that they seek according to their need. Participants reported that the data fields chosen for the Concept Space embody the basic necessary information for an investigation. They also reported that the separation between different fields in the output was very effective in encouraging easy comprehension of the information. More specifically, a number of interface-specific comments emerged from the data collected from the interviews and journals that indicate that use of Coplink Concept Space can lead to increased productivity (RQ1) as defined by reduction in time spent per search.

5.2.1 Time Issue

Perhaps one of the most crucial aspects of the use of Coplink Concept Space in law enforcement is its speed. As one of our participants explained, identifying a suspect between 48 to 72 hours after a crime is difficult. Beyond this time frame, a suspect is able to destroy evidence that may tie him/her to the crime or change his/her appearance to avoid identification. Witness/victim memory of the suspect's appearance also fades within this period. Identification of the suspect ideally should occur within 48 hours of the crime, making establishing useful links for identifying and locating the suspect a crucial step.

Through the journals and interview sessions, each participant was asked to report the time it took to complete at least one particular search task using both RMS and Coplink CS. Table 2 illustrates the reported times for each of the 15 searches using both systems. From participants' reports, we found that in direct comparison of 15 searches, use of Coplink Concept Space resulted in an average of about 30 minutes per search. A t-test analysis of the times reported indicated that, although the differences between search time for RMS and for Coplink Concept Space were not statistically significant (15%), review of other qualitative data from the journals and interviews indicated that subjects reported much quicker response to a query from Coplink CS. The reasons for this reported efficiency fall into two categories.

- *Multiple search entries*
  The Coplink Concept Space allows for the entry of multiple search terms. In the current RMS system, this search capability is not possible, forcing an officer to conduct a number of single searches, then manually compare them. This adds at least a few more hours of work[2]. The Concept Space is able to conduct the same query utilizing multiple search terms within seconds.

[2] This was indeed the case for the searches with a large difference in Concept Space and RMS reported time (i.e., search #1 and search #15 of Table 2).

- *Query expansion*
  As discussed previously, users are able to add to the search any terms returned from the concept space. This point-and-click action to add any number of search terms allows users to expand searches quickly and easily. Being able to append terms to the search and rerunning the search allow officers to explore more searches in a shorter amount to time. In addition, users could also view concept spaces or documents on singular terms returned from previous searches without having to actually type in the query.

Search #:	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***	***11***	***12***	***13***	***14***	***15***
RMS(minutes)	120	45	15	20	60	30	10	12	10	10	20	20	30	15	300
CS(minutes)	10	30	15	5	60	20	5	7	5	3	10	10	20	3	60

Table 2: Reported time breakdown (in minutes) of 15 searches both RMS and Coplink Concept Space.

5.2.2 Interface Layout

As discussed before, the Coplink Concept Space is organized into different types of objects including people, locations, organizations, vehicles, crime types, and weapons. The ability of the system to search across these fields and return associated information from each field is a powerful tool that made it easier for an officer to search quickly for relevant fields. Because the Concept Space searches across all of the six fields, users were able to examine all of the fields simultaneously.

The use of a tabular format to display the resulting concept space allows users to search the relevant information fields quickly. In a criminal investigation, officers are usually seeking specific connections between certain people, places, vehicles, etc. that will enable them to build a complete picture of possible interconnections between objects. The ability to aggregate information fields for searching provides a potent tool for problem solving and crime investigation.

Perhaps the majority of problems encountered by participants in this study were related to the interface, particularly its query entry screen. In the prototype used, because the entry fields were not structured, subjects were required to enter queries in a prescribed format. These entry fields should be redesigned so that it is clear to users where and how to enter search terms. Although the output is returned in a tabular format, participants often reported that an overwhelming amount of information was returned from the system, especially when subjects were interested in only a particular type of information.

6 Conclusion and Future Directions

From this pilot study, we conclude that the use of Coplink Concept Space as a knowledge management and intelligence analysis tool in a law enforcement environment is quite promising. An important aspect of the study is that it dealt with real criminal information, real cases and search tasks and real crime analysts. In addition to providing an intuitive interface, the system's combination of different information types in its associations provides much information of value in the analysis of crimes. Data in a records management system is not useful if the system does not have the ability to pull together the different types of information and to present them in an understandable way. The Coplink Concept Space uses data and transforms them into intelligence that the officer can utilize. Criminals are creatures of habit and being able to understand their habits is an important issue (Joyce 1997). The Coplink Concept Space takes advantage of this characteristic by capturing connections between people, places, events, and vehicles, based on past crimes. As a knowledge management tool, Coplink CS serves to create new knowledge in the form of links between people, places and objects, which in turn results in possible leads for investigation.

From these findings we have been able to determine that Coplink Concept Space was useful to our participants and, furthermore, provided them with a valuable asset in performance of investigative tasks. These preliminary results also indicate that Coplink Concept Space can potentially lead to increased productivity by reducing the amount of time spent for data search. Finally, we have determined that additional development effort is required for redesign of the interface to enable users to be more readily able to interact with and understand the application.

It is evident from this study that the use of knowledge management applications, such as Coplink CS, can have a significant impact on law enforcement. In addition to identifying important functionalities that law officers would like to have in an intelligence analysis tool, this research demonstrates the potential value of knowledge management in law enforcement. Given the favorable results of our Coplink Concept Space study, we are currently redesigning the interface to address some of the usability problems uncovered by this evaluation, including redesigning of screens and improving sorting ability. Based on the experience gathered from this pilot study, we are currently planning to conduct a larger-scale experiment using an updated version of Coplink Concept Space, including a more in-depth analysis of current and potential knowledge management processes. We plan to continue this research effort by expanding it to include participants from different units and job classifications within the Tucson Police Department, while progressively improving the application design.

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