

## Mobile Info Search : Information Integration for Location Aware Computing

KATSUMI TAKAHASHI ,† NOBUYUKI MIURA , SEIJI YOKOJI  
and KEN-ICHI SHIMA

Is the information from the Internet helpful for our daily life? Can the mobile computing support our daily shopping or the sightseeing? With the growth of the Internet, much attractive local information appears. It describes good restaurants, public transportation, or the weather of the district. Though it is very useful in itself, if we want to complete some task such as business trip preparation, we must look for several information sites. But the access methods of the information and the formats of the output are different from each other. On the other hand, it became very easy to get electronic information on the outside of the town today. Because of the progress of the mobile terminal and the communication, we can get information even from the Internet. The mobile computing methodology and the service for utilizing the local information from the Internet is required.

In this paper, we introduce Mobile Info Search (MIS), the research project and the implemented application of NTT Software Laboratories. The goal, the architecture, and the implementation of MIS are described.

The goal of MIS is to collect, structure, and integrate the distributed and diverse local information from the Internet in a practicable form and to provide it with a simple interface to the mobile user of various contexts. Though it is not easy to structure or integrate diverse information or to detect user's context, we do this in the location-oriented way. Local information and the mobile user have their own relevant location. We use this location information for the management and the integration in MIS. The concept and the architecture of MIS are described.

MIS experiment is also an implemented Internet application and has been open to public since September '97. MIS experiment has several features. (1) It has the location-oriented multi search that searches local information from external WWW database servers. It provides shop and services, maps, or public transportation information around the user's current location from the major Internet servers. (2) It has the location-oriented search engine for distributed WWW documents. It searches robot-collected information in the location-oriented structured way. It is named "*kokono Search*". (3) It has a simple interface to every information using latitude-longitude of the user's current location. PHS, GPS, and other devices are served for detection the user's location.

### 1. Introduction

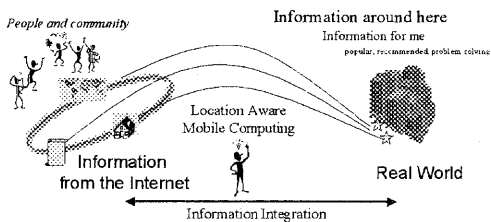


Fig. 1 Concept of Mobile Info Search

These days, the Internet provides various kinds of information. It includes the useful lo-

cal information, such about restaurants, maps, cities, or the sightseeing. Although the growth of the local information made many people familiar to the Internet and the World Wide Web, it can not be handled easily when we want to use it for the daily life. Following are reasons.

- The content is not designed for the mobile computing or the mobile terminal is not powerful enough to handle it.
- As each content is designed individually, the user should search for several sites to complete her request.
- The search interfaces is complicated and differs from each other.

The local information is the information found on the network that is relevant to a certain place. The mobile computing technique that utilizes the local information for the daily life is required.

† NTT Software Laboratories, Nippon Telegraph And Telephone Corporation.

‡ takahasi@slab.ntt.co.jp,  
<http://www.kokono.net/paper/>

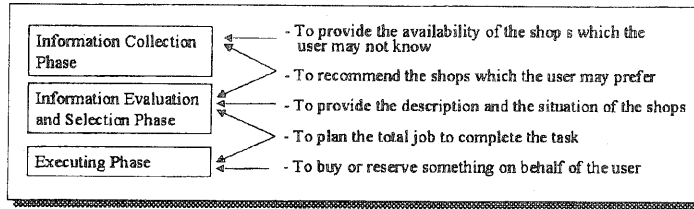


Fig. 2 Daily Shopping Task

Mobile Info Search (MIS) is the name of the research project and the Internet based application<sup>1)</sup>. The long-term goal of MIS is to integrate the local information from the network and the real world information into the handy form for mobile computing users. The local information, will be integrated, includes the people and the community relevant to the location (Figure 1). The core technique required for this integration is how to overlap the computer-synthesized world and the real world. This has been studied in the research field of augmented reality<sup>2)3)</sup>. MIS is characterized by the usage of the location information. MIS regards that every object in the computer and real world has at least the location where the object is. So the location detection of the mobile user and the information plays important role in MIS. We call this way of integration "location oriented information integration".

MIS is also a implemented application. The prototype of MIS service is available on the Internet. The URL is <http://www.kokono.net/>. Current version of MIS provides local information ("kokono" information) such as shops, maps, weather reports and transportation using various locations notifying methods including PHS, GPS and maps on the user terminal.

This paper starts with a study about the task suitable for MIS. In following section, we describe the architecture and the research subject of MIS. In the following 2 sections, we introduce the prototype of MIS and discuss about the experimental result. We conclude this paper with future works

## 2. Mobile Computing Support for Daily Shopping Task

Daily shopping task, such as finding shop for buying something, looking for the restaurant to eat in, is suitable field for our research. Following are several reasons:

- Shopping is the common task
- As some people love to bring guidebooks

or maps, they may be motivated to bring computers

- The shop and service information is often seen on the Internet

Figure 2 illustrates the steps of the Daily Shopping Task. The task is divided into three steps, (1) information collection, (2) information evaluation, and (3) execution. For each step, mobile computing support for the user is possible. One is the information presentation task. Computers are able to find information even if the user can not find it in the real world. Providing information from distributed and diverse environment in a sophisticated way is required. Another one is the recommendation task<sup>4)</sup>. Recently researchers have been solving this task by creating user models or social filtering techniques. The other is execution of the task on behalf of the user. This may be done by software agents<sup>5)</sup> using electronic commerce technique.

We presently concentrate to the first and the second computing task, the information presentation and the recommendation with the location detection task mentioned in the introductory section. In the following section, we discuss about the research issues of these tasks.

## 3. Architecture of Mobile Info Search

Figure 3 and Table 1 illustrates the architecture of MIS. The goal is to collect and organize the information suitable for the user. We use location information of each objects for integration (the idea of location oriented information integration). On the recent Internet, local information is found on the WWW database server as a query result and the WWW server as the static documents. This architecture intends to handle the both sources, the WWW database and the WWW documents.

MIS is located between users and the information sources. This kind of software is called mediator<sup>6)</sup>. Following mediation service is required of MIS.

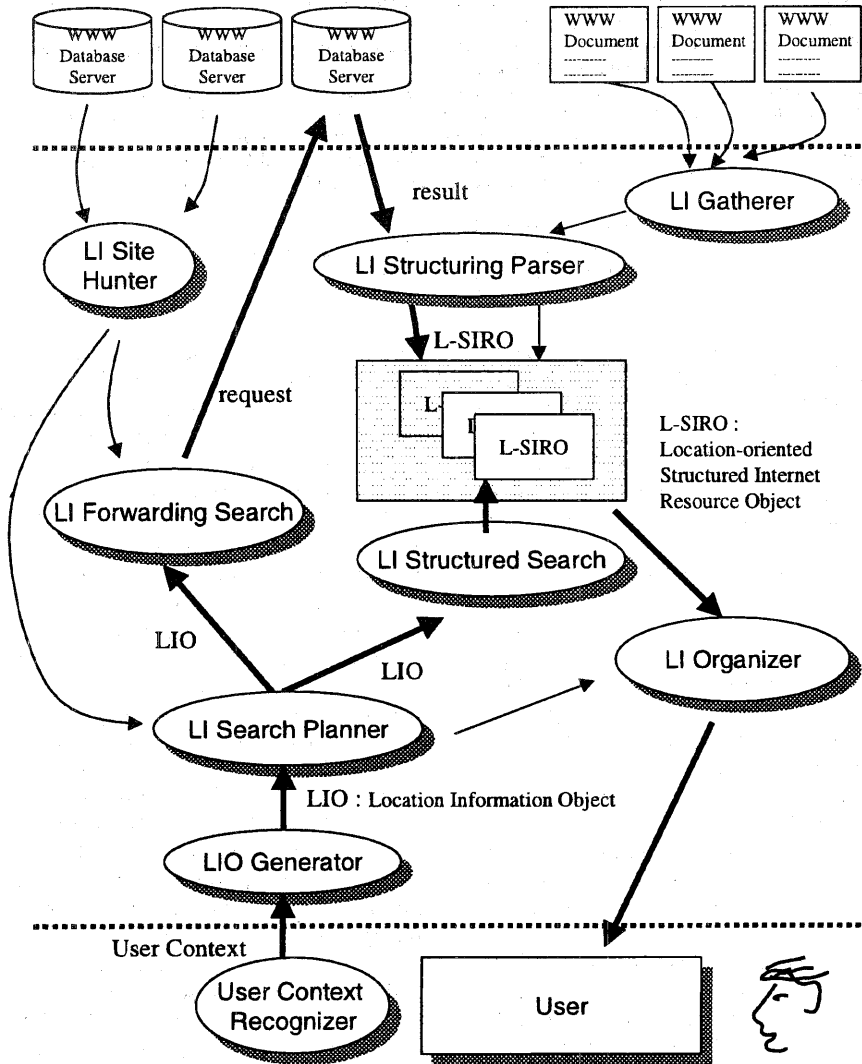


Fig. 3 Architecture of Mobile Info Search

- Recognition of user context: location, action, preference, etc
- Search preparation
  - Determination of the search scope
  - Formulation of the required resources
  - Selection of the relevant resources
- Search execution
  - Unification of the diversity of the resources
  - Selective information collection

- Structurization of the diverse documents
- Structured search
- Information integration
  - Selection of information
  - Recommendation of information
  - Organization of information

**3.1 Search Preparation**

LIO Generator, LI Search Planner, and LI Site Hunter work together to prepare the search.

**Table 1** Functions of the MIS modules

User Context Recognizer	outputs user context
LIO Generator	generates location information object from UC.
LI Search Planner	plans the total search.
LI Forwarding Search	forwarding the users reuest to the Internet sites by formulating the query suitable for the site from the LIO.
LI Structured Search	executes the search by matching the user's LIO with L-SIROs.
LI Structuring Parser	parses the given Internet resource and convert it into the L-SIRO form.
LI Gatherer	collects location information from the Internet selectively.
LI organizer	selects, recommends, and organizes the obtained L-SIROs for the user.
LI Site Hunter	discovers the site and learns the site specific information.
LIO	Location Information Object
L-SIRO	Location-oriented Structured Internet Resource Object
UC	User Context; users location, preferences, ...

Client side module User Context Recognizer outputs the user context. It must include user location. LIO Generator generates the user's LIO. LIO, Location Information Object, represents the user's request. It must include the geographical polygon that restricts the geographic scope of the search. It also includes the other user conditions.

LI Search Planner determines the plan of the total search. The plan describes what kind of resources is required to the request, such as restaurant information, a map, and the access method. LI Site Hunter discovers the WWW Database Server that provides local information from the Internet and learns the site-specific information; such as the information area it provides, the query and the output formats.

**3.2 Search Execution**

This part has two search formations. One is the location-oriented multi search that searches local information from external WWW database servers. The other is the location-oriented search engine for distributed WWW documents.

The location-oriented multi search is done by LI Forwarding Search, LI Structuring Parser, and LI Structured Search. This is a kind of the multi database search or the meta-search. LI Forward Search searches single or multi external servers. It converts the user's request into the query form suitable for the target server according to the knowledge the site specific information LI Site Hunter obtained. A feature of MIS is its handling way of the location information. The LI Structuring Parser described below parses and structures the search results from the external server.

The location-oriented search engine is done by LI Gather, LI Structuring Parser, and LI Struc-

tured Search. This part is similar to ordinary search engines that collects documents, stores and searches them in the internal database. But differs from them by the following reasons. (1) It has a structuring parser that extracts or reasons the location information of the information and stores the information in L-SIRO format. L-SIRO is the data format of MIS that must includes geographical polygon, which describes the relevant area of the information. (2) It allows not only the keyword search, but also the location-oriented structured search. Any information in MIS can be searched by its geographical location in structured way.

**3.3 Information Integration**

LI Organizer works mainly for two services. One is the selection / recommendation of information. It re-selects or recommends the output of LI Structured Search. The decision can be done by the comparing the content or by adopting the external information such from social filtering. Another is organization of information. It deletes the duplication, unifies the results, and combines other sort of information using the plan created by the LI Search Planner, such as adding a map for the restaurant information.

**4. Local information**

**Table 2** Ratio of the local information. A breadth first information collection robot gathered 10,000 documents from the WWW. 85% (8,520) of the total documents do not contain the Japanese address names. Other 15% of documents are regarded as the local information.

TOTAL	no address	Pref.	City	Town	Chome
10,000	8,520	445	549	433	53

Local information is the information that is

relevant to a certain place. The restaurants guides, announcement from the city, and the bargain information from the market are good examples. Though it may not worth world wide or nation wide scale, it is useful for the residents or travellers. Providing local information to the relevant user is important. Table2 shows the availability of the local information from the Internet. About 15 % resources contains the Japanese address name strings. At least they can be regarded as the local information.

5. MIS1: the first test service

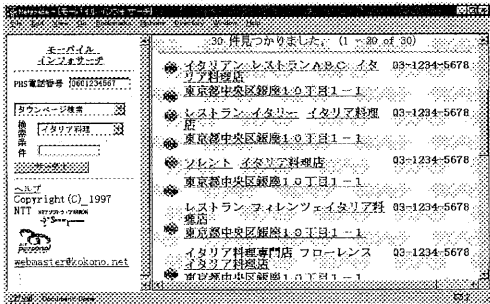


Fig. 4 Nearest Italian restaurants from Internet TOWNPAGE, <http://townpage.isp.ntt.co.jp/>. The left window of the picture is the index of MIS. The right is from the external servers.

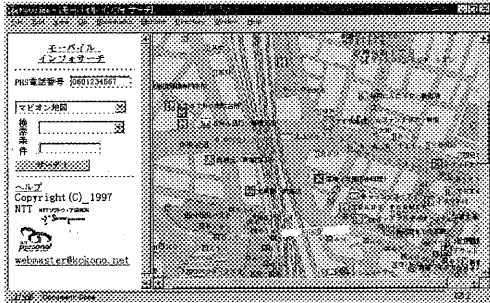


Fig. 5 Map of the current location from Mapion, <http://www.mapion.co.jp/>.

MIS1 was the first test of MIS. Figure 4 and 5 shows the service available on the MIS1. It featured the the simple interface to the various kinds of resouces as the first step prototype of the location-oriented multi search. Users only have to select the remote service from the menu of MIS1. Query are created by MIS and the results are displayed automatically to the user terminal.

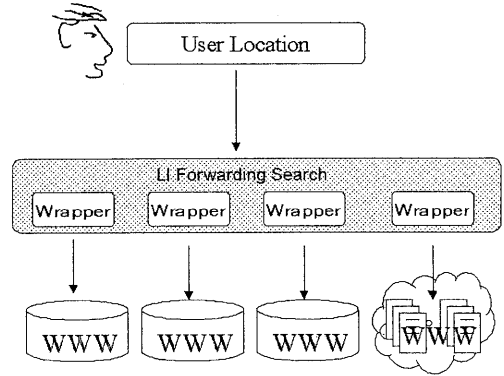


Fig. 6 Brief architecture of MIS1

This experimental service was done by NTT Software Laboratories and NTT Central Personal Communications Network Inc. as an open WWW service. It lasted from September '97 to May '98. About 400 users accessed MIS1 using the LI-PHS. 11 WWW services by the courtesy of the 8 companies were available from the MIS1. It included Yellow Pages, city information such as hotels and restaurants, and map services. 65 percent of total accesses were for the map services.

It employed the trial version of LI-PHS (location information PHS that notifies the current location in longitude-latitude form) for detecting the user's current location. User can search shops or maps around the current location.

A brief architecture is shown on Figure 6. Hand-coded Wrapper software was implemented as the LI Forwarding Search. The role of the LI Site Hunter was left for the operator of MIS. LI Forwarding Search converts user's location into the query of the target site in following way. It has the site specific information such as the query format, and the knowledge about the location representation. Representation of the location is various. One server only accepts the longitude-latitude, another does the address, station name, etc. It can convert each representation one another. As it had no structured search method, the result from the remote host is returned directory to the user<sup>7)</sup>.

6. MIS2 : introducing kokono Search

MIS2 is the newest version at the present. This service has been available since June '98. It differs from MIS1 on the following points. (1) LI-PHS (commercial version), GPS, maps, and textual information that specifies a location

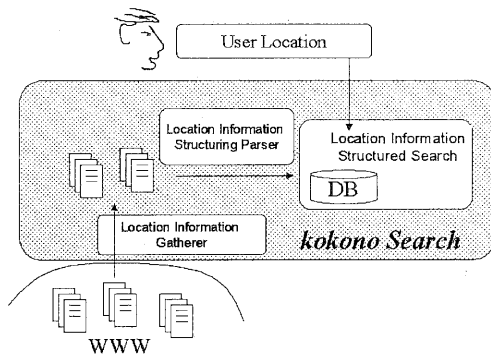


Fig. 7 brief architecture of *kokono Search* newly introduced to MIS2

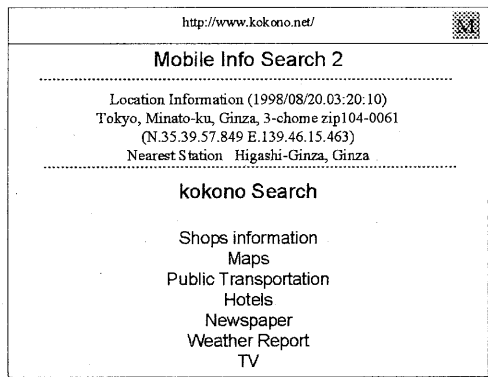


Fig. 8 Index page of MIS2. This page is automatically displayed by accessing MIS2. User's current location is displayed as the address, the longitude-latitude, and the nearest station on the top of the page. *kokono Search* and other seven categories follow. Services for the external sites are operated by selecting the services categorized into the seven menus.

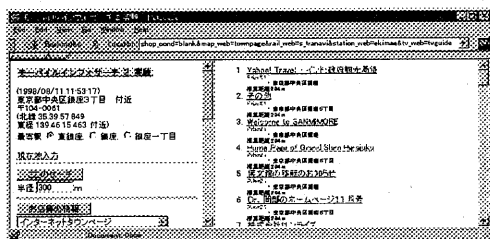


Fig. 9 Example of *kokono Search*

such as address names, station names, zip code are available for the location detection methods. (2) Added location-oriented search engine named "*kokono search*".

Figure 7 illustrates the overview of the *kokono search* newly introduced to the MIS2. *kokono*

*search* is the location-oriented search engine that only handles the local information. Local information gathered by LI Gatherer is converted into L-SIRO. LI Structured Search performs the search based on the longitude-latitude. It calculates the distance between the L-SIRO and the LIO of the user and outputs the L-SIROs within a certain range. The ability of LI Gatherer is shown in figure 10. It collects 2.3 times as much information as the normal breadth-first collection robot. LI Gatherer employs the heuristics to calculate the collection priority. The collection priority of the uncollected resource is determined by estimating the resource is the local information or not. It is estimated local information, if the link letters contain the address strings<sup>8)</sup>.

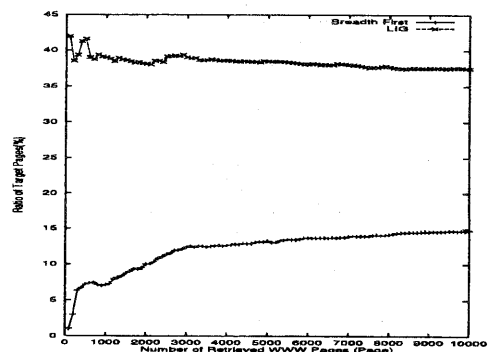


Fig. 10 Comparison between the selective information collection by LI Gatherer and the breadth first collection

## 7. Related Work

As the WWW application, several location-oriented services are proposed. Yahoo<sup>9)</sup> local provides the localized version of the yahoo in US. By specifying the city, an index page of the local information appears. Mobile Link<sup>10)</sup> is the service for car navigation systems in Japan. It provides driving related information.

We have been studying on the information retrieval for the mobile environment users. Intelligent Page<sup>11)</sup> is our first trial. We intended software agents to retrieve information from the diverse resources on behalf of the user. Action Navigator<sup>12)</sup> employed recommender architecture using the other user's subjective information.

There are several backgrounds for this research. One is mediator<sup>6)</sup>, which is the middle

ware service between the end user and the data resources. It integrates diverse data from multiple sources, reducing data to the appropriate level, and restructures the results. TSIM-MIS<sup>13)14)</sup> and the I3<sup>15)</sup> are the major research project for the mediation.

There are several Internet based research applications similar to MIS. MetaCrawler<sup>16)</sup> is the parallel WWW search service. It provides single interface to the user, collects the results from the search engines, and organizes the results. Bargain Finder<sup>17)</sup> and Shopbot<sup>18)</sup> both finds products from the servers and compares the prices or other spec. These researches are close to MIS in the motivation and goals. But MIS is different from them by the location-oriented information structuring and organizing way.

## 8. Conclusion

The goal, the architecture, and the implementation of Mobile Info Search are described.

The goal of MIS is to collect, structure, and integrate the distributed and heterogeneous local-information from the Internet in a practicable form. It also aims to provide simple interface to the mobile environment user of various contexts.

In the architecture of MIS, we defined roles for each functions. Though not all of the functions are implementable at this moment, they will act as autonomous software-agents if we solve the issues we assigned. We will concentrate on designing several agents following.

- LI Forwarding Search and LI Site Hunter to be an agent that learns the search process automatically and search the external resource server on behalf of the user.
- LI Structuring Parser to be a parser that automatically finds the structure of the document and converts it into a structured form.
- LI Organizer to be an agent that selects or recommends information autonomously for the user using the analysis of the content of the information or the comments and opinions from the community.

MIS is implemented for an WWW based experimental test which has been operated since September of '97. The URL is <http://www.kokono.net/>. This service features the location-oriented multi search for the major local-information servers and the location-oriented search engine for the distributed WWW documents. It also employs

the PHS or GPS for detecting the user's current location.

The goal, providing the local information from the Internet in a practicable form, can not achieved only by the software technology. But also the providers that supply useful information and users that enjoy and refine the information are required. We will continue our study with them in a practical way.

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