*F*OLKSOMAPS - Towards Community Driven Intelligent Maps for Developing Regions

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***Abstract*—**

Many services taken for granted in the developed world are often missing from the developing countries. One typical example is that of map systems that form the basis of several location driven services. Its heavy reliance on content, provides a huge barrier towards building such systems. Further, in developing countries like India, the infrastructure typically has a history of unplanned development, leading to unorganized addresses and absence of standard naming conventions for roads. Detailed map systems such as online maps have only recently started becoming available but for major cities. Remote towns and villages remain out of reach till date.

In this paper, we investigate a community-driven approach for creating maps in developing regions - following Web 2.0 principles, but not entirely relying on the existing Web. Our system, dubbed FOLKSOMAPS is an intelligent, community constructed map system, particularly architected with developing regions in mind. We present the design of FOLKSOMAPS, followed by an implementation of our proof-of-concept system. We present user studies aimed at understanding the uptake, usability and utility of FOLKSOMAPS. The results indicate a strong need for such a community-generated mapping ecosystem.

I. INTRODUCTION

As defined in Wikipedia: *"A map is a visual representation of an area's symbolic depiction highlighting relationships between elements of that space such as objects, regions, and themes. Maps may represent any space, real or imagined, without regard to context or scale"*

The map systems in developed countries have advanced to a state where users can view street level information in 3D and annotate the maps with their own personalized content[1]. Such systems include Google Earth[2] and MSN's Live Maps[3] etc. Due to the prohibitive development cost involved, offering such systems becomes viable if profitable services can be offered on top of the core content base. The existing map systems generate revenue from services such as driving directions, finding local businesses and advertising.

In contrast, sparsely populated semi-urban and vast rural areas of developing countries such as India do not have detailed map systems built for most locations. Further, the semi-literate, low income, Non-ITsavvy population [1] residing in these areas cannot use such services even if they were offered in the manner done today. Furthermore, lack of stable infrastructure including electricity, internet connectivity and the lower purchase power of people, also complicate the situation further.

The urban metropolitan cities, however, are beginning to experience such services as the factors affecting semi-urban/rural areas are not applicable there. Examples in India include MapMyIndia.com and MapsOfIndia.com. These websites provide detailed mapping information for metropolitan cities but contain only high level content for other areas. Even in metropolitan cities (about 100 million people stay in Indian metropolitan cities [2]), the (online) maps often do not contain enough detail/content to get driving directions from door-to-door. Secondly, lack of structured addressing conventions and poor road signs makes it difficult to follow the maps[4]. So, even people comfortable with maps, often need to ask people on the streets to find their way.

To overcome the prohibitive cost of developing and maintaining such map services for semi-urban areas, as well as to address the limitations of using maps in urban cities, we propose utilizing the collective efforts of the community who would be motivated to populate, maintain and access content for their benefit. In this paper, we present FOLKSOMAPS a community driven map system that leverages Semantic Web [5] technologies to create and manage a community generated knowledge base and makes use of web and voice applications [3] to provide access to its services.

It is non-trivial to build such a system since several issues crop up. For instance, due to unplanned, historic development over centuries, cities, towns and villages in developing countries typically do not have well structured naming of streets, roads and houses. For example, postmen in villages often need to know the inmates by name in order to reach their houses. This leads to imprecise directions and key landmarks become very important in specifying locations and directions. We make use of such insights among other obtained from a user study for the design of our system.

[1]http://www.wikimapia.org
[2]http://earth.google.com
[3]http://maps.live.com

[4]A tiny segment using GPS navigation might get along in the cities, however they become handicapped outside urban areas due to lack of maps.
[5]http://en.wikipedia.org/wiki/Semantic_Web

II. Survey of Current Models

In this section, we present results of survey done with end-users who depend upon location/map-based information for their daily business and/or personal needs. We investigate their current models to identify how they manage and use location information.

A. Survey Process

We selected the subjects considering their technical background, so that we get a good variety. We targeted two categories of people: (1) *ITsavvy*: People for whom computers and Internet is part of life (2) *Non-ITsavvy*: People who do not use computers and Internet (reasons range from them being less literate to being economically challenged) but use low-end cellphones (primarily for communication). We believe that such a mixed set would be able to provide us the right insights to evaluate the need for a community-driven map for developing regions.

With the Non-ITsavvy class, we conducted the survey in a face-to-face interview mode, where specific questions were asked, albeit in a very informal and interactive manner. On the other hand, we circulated our questionnaire to the ITsavvy class and requested them to fill it up independently. The questions were targeted to understand the subject's current model for finding landmarks and directions in the city. There were 21 questions in total. At a high level, our aim was to understand the following:

1) How do people find out points of interest (ranging from very small mom-and-pop shops to popular landmarks) ?
2) How much do they rely on maps or people on the streets? Are all their information needs satisfied by maps?
3) How do they provide location information (information about landmarks, directions) to other people ?
4) Would they be interested in consuming and producing information for a community-driven map system ?

We surveyed a total of 40 subjects, with 24 from the ITsavvy category and 16 from the Non-ITsavvy category. The average age of the ITsavvy subjects was 26.37 years, ranging from 21 to 34 years. The average age of the Non-ITsavvy subjects was 32.68 years, ranging from 21 to 62 years. Most of the Non-ITsavvy subjects either did not have a formal education or primary education (10th standard) and were working in the city (security guards, car mechanics, cab drivers etc). The ITsavvy set consisted of engineers, editors, reporters, business owners etc. We summarize the key findings in Table I.

TABLE I
CURRENT MODEL: SUMMARY OF USER RESPONSES

Responses	Non-ITsavvy	ITsavvy
Use maps	0%	66.6%
Rely on people to find shops	68.75%	75%
Rely on people for directions	87.5%	67%
Want precise directions	35.7%	58.3%
Will upload content	87.5%	79%

B. Results of Survey with Non-ITsavvy Subjects

As expected none of the subjects in Non-ITsavvy category used maps to find information about locations. In fact, many were not even aware of the concept of maps. A majority of them mentioned that they currently rely on asking people on the street to know the location of a shop in an area. They ask people nearby or ask their friends or colleagues about the location. The others mostly find a shop on their own. 3 subjects mentioned that the information that they receive from people on the street are often not correct and not accurate, and this leads to frustration. About 87.5% of these subjects rely on other people to provide them travel directions. However, only a small section of these felt the need for precise directions (needed only in congested residential areas).

About 75% people preferred the choice of a phone based interface and were willing to upload content. About 56% also mentioned that they would be willing to pay for such a service.

Key Insights : Use of maps for Non-ITsavvy segment is nil and they rely primarily on others for travel directions. Most prefer a voice based interface and many are willing to pay for the call. Also, precise directions are not necessary for this user segment.

C. Results of Survey with ITsavvy Subjects

As shown in Table I, a majority of ITsavvy subjects make use of maps for finding locations and directions to locations. The interesting part is that even with maps, a majority of these people rely on other people for location related information. This is primarily because the unstructured nature of city layout coupled with broken, missing, faded, hidden (behind posters, graffiti) or even inconsistent sign boards make it almost impossible to rely entirely on a map for travel directions. Many a times, the maps do not contain fine-grained information in the first place.

2 out of 24 subjects mention that maps help them to find exact destination, while 19 mention that they rely on maps, only for a *rough* idea of the direction or rely on public transportation and mostly ask people (if road signs are not enough) for the exact location once they reach nearby their destination.

Most subjects mentioned it would be helpful to have a phone-based location and direction finding system in addition to the web based interface, and about 79% expressed interest in *contributing* to the service by uploading content either over phone or through a web-based portal.

Key Insights : Even though this segment makes heavy use of maps, they still are forced to rely on other people due to various factors. Many people prefer rough directions in the beginning (as they probably know the city) of their journey, and want detailed directions only towards the end. People rely a lot on community information, and asking people on the streets for directions and location is a common practice.

III. Understanding Technology Requirements

FOLKSOMAPS harnesses user-generated content about locations and aims to provide map-based services that represent user's intuitive way of finding locations and directions in developing regions. We conducted an additional survey with the aim of understanding the technological requirements for FOLKSOMAPS. In this survey, we primarily focused on understanding the ways in which users express directions and location information. In addition, to provide the subjects with an idea of the system, we created a paper prototype that shows how a user would typically access the services and populate content to it.

The paper prototype was an audio recording of system prompts and user responses. We created audio prototypes for two scenarios 1) User calls FOLKSOMAPS to find directions to a particular location 2) User calls to add information about a location These prototypes were created using audio recording and editing tools and were used to illustrate the concept of FOLKSOMAPS to some users.

We conducted this survey along with the working model survey with a total of 40 subjects - 16 from Non-ITsavvy and 24 from ITsavvy community. Here is a sample of the questions we asked:

- How do you give directions to people on the road or friends?
- How do you describe proximity of a landmark to another one?
- How do you describe distance? Kilometers or using time-to-travel?

A. Non-ITsavvy Community

When asked about how they personally give directions to anyone who asks them, 12 out of 16 subjects said they make use of landmarks to explain the direction to the destination. They use names of big roads to describe a location, and use "near to", "adjacent to", "opposite to" relations with respect to *visible or popular* landmarks to point the destination. 5 subjects said they can provide exact directions within one kilometer of the destination. 4 said that they usually give directions up to the nearest landmark thereafter which people will need to ask again. 9 subjects felt confident about guiding a person to the exact landmark.

Interestingly, 6 of 16 subjects said that they use time (only) as metric to measure the distance between any two locations. 12 out of 16 subjects mentioned that they use either time or kilometers. 3 subjects mention that they sometimes use "rough" distance measures in terms of kilometers. One subject did not have the notion of kilometer as a measure at all.

TABLE II
COMMON RELATIONSHIPS USED TO EXPRESS RELATIVE LOCATION

Relationships	Non-ITsavvy	ITsavvy
A isNear B	93.75%	67%
A adjacent to B	81.25%	45.8%
A opposite B	75%	75%

B. ITsavvy Community

Only 2 out of 24 subjects tell people to use maps to guide them to their house. The rest either use landmarks on roads to guide the person. This came as a surprise to us, as we were expecting this community to be more reliant on maps. 10 out of 24 subjects usually are able to give exact direction to a known landmark using relationships as shown in table II. 13 subjects mentioned that they guide the person to the nearest big landmark and then guide the person by phone or pick the person from the landmark. 14 out of 24 subjects felt confident that people should be able to follow the way they guide. Table II shows the most commonly used relationships to describe proximity of a landmark to another one. Typically, while giving directions, such relations are used to relate a less visible or a less known landmark with a more visible or popular one.

Interestingly, 21 out of 24 subjects either use both time and kilometers as a measure of distance and only 3 subjects claimed to use only kilometers to represent distance. 17 out of 24 participants never use zip codes while 6 use them rarely.

This study, coupled with insights obtained from the survey of current models, has been useful to design the ontology as well as the output of FOLKSOMAPS- differentiating it from traditional map-based systems prevalent today.

IV. THE TECHNOLOGY

Based upon insights gained from the surveys we developed FOLKSOMAPS – a community generated map system. FOLKSOMAPS is designed to be populated by end users for their own consumption. This section presents the architecture and design of FOLKSOMAPS system while highlighting design choices that differentiate it from the established notion of map systems. They key differences are listed below.

- It relies primarily on user generated content rather than data populated by professionals.
- It strives for spatial integrity in the logical sense and does not consider spatial integrity in the physical sense as essential. For instance, information such as "Building A is located near to circle J after taking first turn on the circle while arriving from location B." is treated complete and correct for tracing path from B to A. In other words, the direction and distance parameters are not specified in precise terms. This is because, as evident from the surveys, the end users are not likely to specify physical data while populating geographical landmarks.
- A visual representation is not essential to FOLKSOMAPS which is important considering the fact that a large segment of users in developing countries do not have access to Internet.
- FOLKSOMAPS is non-static and intelligent in the sense that it infers new information from what is entered by the users.
- The user input is not verified by the system and it is possible that pieces of incorrect information in the knowledgebase may be present at different points of time. FOLKSOMAPS adopts the Wiki model and allows all users to add, edit and remove content freely. From the established Wikis on the Web we expect that the community would actively remove or edit invalid content and keep

the maps up-to-date. However, to limit malicious intent, the system places two minor restrictions described in the next section.

A. Conceptual Design

We use the notion of a *landmark* as the basic unit of representing nodes in FOLKSOMAPS. A *location* represents more coarse grained geographical area such as a village, city, country etc., in addition to also representing a landmark. The core knowledgebase of the system needs to capture few key logical characteristics of locations that users are interested in specifying and making use of. These include the following:

- Direction i.e. the positioning of a location relative to another one. From the surveys we found out that users are comfortable with providing relative information such as 'towards left of', 'on the right side of' etc. instead of absolute direction in the form of north, east, west, south compass points.
- Distance i.e. the measure of amount of space between two locations. This can be represented as numbers along with units in which the distance is expressed. From the surveys, we learnt that FOLKSOMAPS needs to consider both time and metric units to represent distance.
- Proximity and Reachability i.e. representation of information stating that one location is in close proximity to another or is reachable from another respectively.
- Layer i.e. granularity of geographic area that a location name represents. It could be a division as big as a whole country or as small as a village. The notion of direction and distance from a location, are interpreted with respect to the layer that the location represents. In other words, direction and distance could be viewed as binary operator over locations of the same level. For instance, 'is towards left of' would be appropriate if the location pair being considered is <Libya, Egypt> or say <South Korea, Japan> but not if the pair is <Sheraton waikiki hotel, Mexico> where Sheraton Waikiki hotel is in Honolulu, Hawaii.

We model the knowledgebase for representing and storing these concepts in two parts. The first one makes use of Web Ontology Language (OWL) [6] to model the categorical characteristics of a landmark, i.e. direction, proximity, reachability and layer. Use of a Semantic Web language to represent relationships between locations brings in the advantage that the system can reason on those and infer newer relationships not explicitly specified by users of the system. The second part makes use of a graph database to represent distance between landmarks which is numerical data. The two modules are used in conjunction to generate answers to queries submitted by users to the system.

B. User Interaction

The user interaction aspect is critical for the success of FOLKSOMAPS. This is especially true since users would tend to query the system either when they are stuck on road looking for directions or before starting on a trip and would be pressed for time. Further, the user set also consists of people who might be illiterate or semi-literate or not very ITsavvy. Considering these, we discuss three different modes of interaction that the system needs to support to cater to different user segments for different tasks.

There are three main tasks that a user can perform with the system. First is to find a landmark/location by specifying its name possibly including some related information such as nearby places or enclosing area. Second, users can ask for tracing a path between two locations. Third, users could add to the knowledgebase by adding information about a location/landmark that they know of. In addition, some or all users may also be given the facility to edit or remove entries from the knowledgebase.

We also consider three sets of users who would interact with the system. On one extreme, the users of FOLKSOMAPS are ITsavvy people who can access it over the Web. FOLKSOMAPS provides a web interface to these users for submitting queries as well as to update its knowledgebase by adding new locations and related information. On the other extreme, we have users who are illiterate or semi-literate and cannot afford to have high end devices but can use an ordinary low end phone for voice communication. Studies done earlier [3], [4], [5] suggest that a voice-based interaction works well for this user segment and for them FOLKSOMAPS supports a voice based interface for querying the system. The third segment of our users lies between the two extremes and consists of mobile people with low end devices who are familiar with SMS. FOLKSOMAPS allows SMS based querying and location updates in a constrained form for these users.

C. System Architecture

Figure 1 shows the architecture of the FOLKSOMAPS system. As shown, users can upload content into the knowledgebase through an SMS interface, a web based interface or through a voice interface. Similarly, the content delivery to the consumers also happens through these multiple interfaces. The knowledgebase consists of an ontology and a graph database. An ontology is used as the primary repository of the location information. This is because the user generated content cannot be expected to be complete. It is essential to be able to infer facts not explicitly populated by users in order to have a pragmatic map system. The graph portion of the database captures additional information that either cannot be expressed appropriately in the ontology or needs to be processed differently. This includes numeric data such as distances between locations.

The central block of the figure forms the core of the runtime system of FOLKSOMAPS, acting as an intermediary between the consumers of the service and the knowledgebase. It consists of a module each corresponding to the tasks listed above, namely location insertion/removal, location finding and path finding. It provides a similar interface to the users across interaction modalities for information upload and retrieval.

[6] http://www.w3.org/TR/owl-ref/

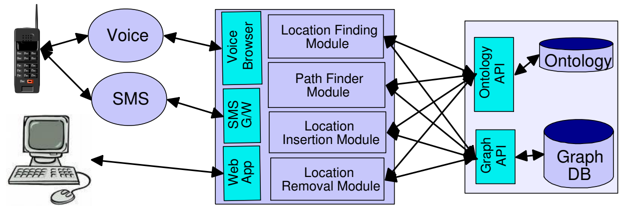

Fig. 1. The System Architecture

In the next section, we provide some details of the design of FOLKSOMAPS knowledgebase.

V. KNOWLEDGEBASE DESIGN

The FOLKSOMAPS knowledgebase consists of two parts. A graph database and an ontology of locations. The graph database is primarily a graph data structure based representation of the locations. The locations are represented by nodes and the edges between two nodes of the graph are labeled with the distance between the corresponding locations. Given the insights gained from user surveys, precise distances (and exact directions) are not key components of a map for our target users. Therefore, Graph DB is an optional component and we do not discuss it in this paper.

The other, more important, part that makes FOLKSOMAPS intelligent, is the ontology of locations that helps construct paths and retrieve information that no user may have explicitly entered. This is what we describe next.

A. The Location Ontology

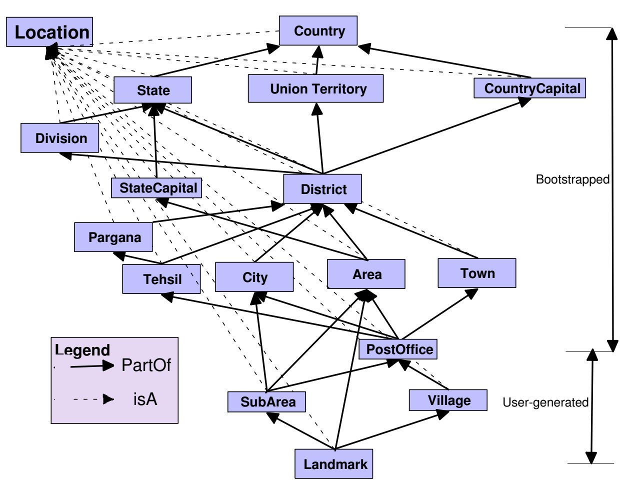

Fig. 2. The Folksomaps Ontology Design

Figure 2 depicts the location ontology that we created. As shown, all concepts in the location ontology derive from concept *Location*. The highest level concept that the ontology currently represents is *Country*. The rest of the concepts are defined specific to India keeping in view the administrative structure of the country [7].

[7]http://en.wikipedia.org/wiki/Subdivisions_of_India

Not shown in the figure is another concept labeled *Space*. It is defined as complementary and disjoint to *Location*. This became necessary since OWL ontologies follow the *open world assumption*[8] which means that a relation not explicitly asserted in the ontology being reasoned upon cannot be concluded to be false since it may be specified elsewhere.

```
<owl:ObjectProperty rdf:about="&commgis;partOf">
  <rdf:type rdf:resource="&owl;TransitiveProperty" />
  <rdfs:domain rdf:resource="&commgis;Location" />
  <rdfs:range rdf:resource="&commgis;Location" />
</owl:ObjectProperty>

<owl:Class rdf:about="&commgis;Landmark">
  <rdfs:subClassOf rdf:resource="&commgis;Location"/>
  <rdfs:subClassOf>
    <owl:Restriction>
      <owl:onProperty rdf:resource="&commgis;partOf"/>
        <owl:allValuesFrom rdf:resource="&commgis;SubArea" />
        <owl:allValuesFrom rdf:resource="&commgis;Area" />
        <owl:allValuesFrom rdf:resource="&commgis;Village" />
    </owl:Restriction>
  </rdfs:subClassOf>
</owl:Class>
```

Fig. 3. OWL definitions of **landmark** class and **partOf** property

- **Relationships**
  Each location can be related to other locations to logically represent the geographical relationship that exists between them in the world. As can be observed from the figure, apart from **isA** relation of all locations with the *Location* concept, each location concept is related to one or few location concepts through a **partOf** relation. This relation helps establish the *layering* between various geographic locations, as identified in Section IV.
  Landmarks lie at the lowest strata of the ontology. Since the administrative structure of a country remains relatively static and is generally well known, the top part of the ontology can be bootstrapped in advance and users can be allowed to contribute instances from the lower half consisting of landmarks and sub areas. Also, some key landmarks such as historic sites of national importance and key government offices such as the parliament could also be pre-populated into the ontology.
  The ontology supports several relationships in order to be able to specify the four key characteristics of a location defined in Section IV. In the interest of space we present here details of only two key relationships – **nearTo** and **connectedTo** that model the proximity and reachability characteristic respectively.
  Relation **nearTo** is a symmetric relation defined between two locations to express the fact that they are in close proximity to each other. This could intuitively mean a few hundred meters or a kilometer. The *logical* integrity of nearness can be applicable to locations other than landmarks. For example, two towns in the same *district* can be considered *nearTo* each other, compared to two towns in different districts. To capture these, for *SubArea*s a **sameTown** relation and for *Area*s a **sameDistrict** relation and so on are defined. However, for the purpose of this paper, we stick to the basic **nearTo** relation between landmarks. All the modules make use of this relation

[8]http://en.wikipedia.org/wiki/Open_World_Assumption

to search for or add/update locations specified in user's query.

The **connectedTo** relation is a symmetric as well as a transitive relation. It expresses the fact that two locations are reachable from each other via one or more paths that can obtained from the ontology facts. Users may add **connectedTo** relation between location instances that they are familiar with. FOLKSOMAPS makes use of the ontology to infer new **connectedTo** relations based upon these individual assertions. The Path Finder module relies on this information to compute paths from the individual connections supplied by users.

- **Bootstrap Process**

The FOLKSOMAPS system could be bootstrapped from existing databases to populate instances of location types in the upper part of the ontology. Two such sources of data in the absence of a full-fledged Geographical Information System (GIS) system come from the Telecom Industry and the Postal Department. While postal department is obvious, the telecom companies also maintain database of various circles that they operate in. Given that mobile phones have penetrated into the remote rural areas as well, the upper ontology can be populated from their data as well. While the actual GIS data benchmarking require significant efforts and cost on the field to map the spatial data, the telecom and post office data give a very good logical view of the locations. This complements our system's design goal of providing a logical view rather than a spatial view to the users.

B. Knowledgebase API

This subsection describes the API that we built for accessing the knowledgebase for finding path, location or for adding a landmark.

1) *findLocation() :* This method allows a user to search for a location specified by its name. Optionally, extra information can be supplied which includes the landmark's relationship with another landmark or its attributes.
2) *findPath() :* This method takes source location name and destination location name along with a filtering criteria and returns a list of locations that represent the path traversal from source to destination. The location names can optionally be augmented with a list of nodes that represent meta information about the position of the source or destination node in the ontology. The filtering criteria specifies additional restrictions (e.g. only traverse paths connected by a *nearTo* relation) on the path traversal algorithm.
3) *doesExist() :* This method determines whether the supplied landmark name already exists in the knowledgebase.
4) *addLandmark() :* This method allows the user to insert a new landmark into the knowledgebase. It takes the name of the new landmark and also its immediate parent, i.e. its *SubArea* name. Optionally, its next parent, i.e. *PostOffice* is also supplied. If this landmark already exists, this new entry is rejected. Also, this landmark is added only within the context of its parent, i.e. it's *SubArea*. If the *SubArea* supplied does not exist, then also the landmark is rejected. In addition to the landmark name, the user can optionally specify other meta information such as which all landmarks are located nearby and to which all landmarks is this new one is connected to.
5) *editLandmark() :* This method allows you to search for a landmark or a relation instance and allows you to delete it in the fashion similar to addLandmark().

In the next section, we describe our prototype implementation that we used to conduct user studies.

VI. PROOF-OF-CONCEPT IMPLEMENTATION

We have implemented a prototype of FOLKSOMAPS and deployed it at our lab. The prototype's knowledgebase includes the ontology module and does not have the optional Graph module. We used OWL to implement the ontology. We implemented the FOLKSOMAPS modules for finding a location, finding a path and adding a landmark. The ontology API used is JENA[9] with Pellet reasoner[10]. We bootstrapped the system with data about New Delhi, the capital of India and initialized it with **SubArea**s located in a couple of **Area**s under **South Delhi** district. We implemented a Web based interface as well as a Voice based interface for this prototype. The Web based interface supports all the implemented modules and is developed using Java Server Pages (JSP)[11]. On the other hand, the Voice based interface is accessible over a phone call and supports find location and find path modules. It is developed using JSPs and VoiceXML[12].

Users are allowed to populate the FOLKSOMAPS system with new landmarks and associate them to the **SubArea** which they belong to. Additionally, users can also provide information about the landmark. This includes other landmarks located near to the one being added, and other landmarks that are connected to this by road etc. Figure 4 shows a partial snapshot of the populated Folksomaps knowledgebase.

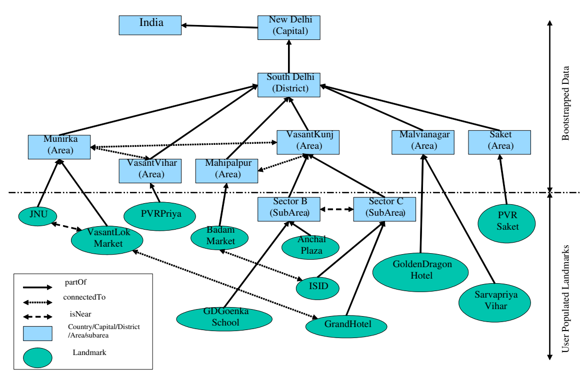

Fig. 4. A partial snapshot of populated ontology

[9]http://jena.sourceforge.net/
[10]http://pellet.owldl.com
[11]https://java.sun.com/products/jsp
[12]http://www.w3.org/TR/voicexml20/

Users are also allowed to query FOLKSOMAPS for getting location information and directions. Figure 5 shows the screenshot of webpage for getting directions from a source to destination location. Figure 6 shows the flowchart for querying through the Voice based interface. Error steps are not shown in this flowchart. The results from FOLKSOMAPS reflect the ways in which people would essentially give directions.

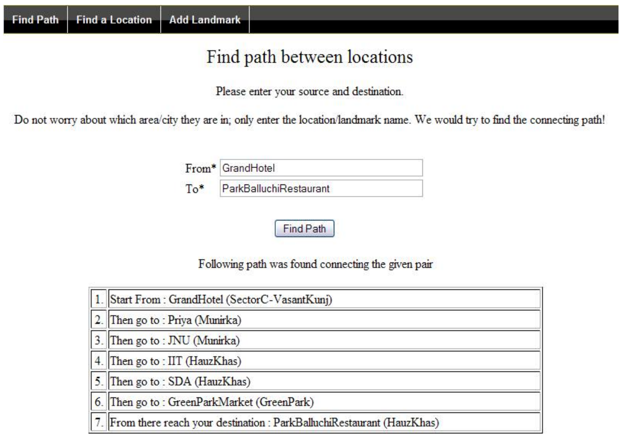

Fig. 5. Web UI showing the results of querying for directions

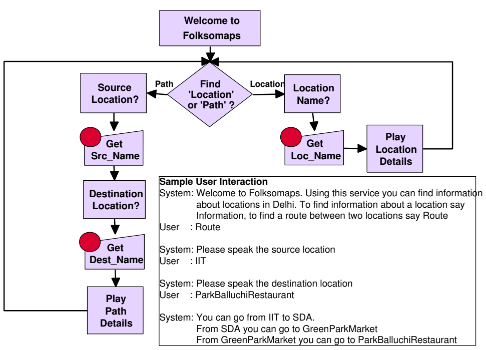

Fig. 6. Voice UI flow for querying FOLKSOMAPS. Red dots indicate voice recognition steps.

VII. SOLUTION SURVEY

In this section, we present results of user studies we conducted to verify the benefit and acceptability of the proposed system. We further present insights that we obtained from users while conducting the survey. For the ITsavvy segment, we let the subjects try FOLKSOMAPS through the web based user interface of the system. For the Non-ITsavvy segment, we conducted the survey with the voice based interface of FOLKSOMAPS[13].

A. Survey Process

For ITsavvy survey participants, we started with a small introduction before giving them access to the FOLKSOMAPS website. In addition to the bootstrapped data, the knowledgebase also contained some pre-populated locations. We requested them to populate content into FOLKSOMAPS while restricting the locations to a set of 6 **Areas** in South Delhi **District**. This was done so that the content populated does not get thinly spread out and is relatively rich for querying [14]. After populating some landmarks known to them, users then queried the system for finding information about other landmarks and travel directions to those. After this, we asked them a few questions about their view of FOLKSOMAPS system.

For the Non-ITsavvy subjects, we briefed them about the purpose of the proposed system and gave an explanation of the prototype. We then walked them through the voice based interface, by querying for some location and requesting for a path to that location from another. This was followed by a question answering session. All subjects grasped the concept fairly quickly and were able to see the benefits they could derive from such a system.

B. Results of Survey for Non-ITsavvy subjects

We conducted a total of 22 surveys with Non-ITsavvy participants using the voice interface. The set of interviewed people consisted of porters, security guards, elderly people, draughtsmen, waiters and service staff. The results are tabulated below.

Fig. 7. Interviewing the Non-ITsavvy users

TABLE III
SUMMARY OF NON-ITSAVVY USER RESPONSES TO FOLKSOMAPS

Questions	Yes	No
Would you call to get directions?	100%	0%
Prefer calling over asking people on the street?	82%	18%
Ready to pay for call (else want ads)?	45%	55%
Will upload content?	73%	27%
Voice Interface preferred over SMS?	91%	9%
Results need to be very accurate?	86%	14%

As can be seen from Table III, all the subjects surveyed were interested in using FOLKSOMAPS system. Most of them preferred the option of calling up a number for directions rather

[13]The voice based interface was in Hindi language and allowed a restricted set of landmarks to keep the speech recognition accuracy high for the prototype

[14]We envision that the actual content in a deployed system will be much more richer than the content populated by the survey participants.

than asking someone on the street. Apart from convenience, this overwhelming response can be attributed to a couple of reasons. First, asking on the street does not always work. On a secluded road, there may not be anyone to ask. Several times people end up giving wrong directions (possibly to hide their lack of awareness or to not appear rude) leading to precious time spent traveling on a wrong route and recovering from it. Also, the point of view of street vendors who often get enquiries from passersby about directions is quite interesting. They candidly admitted that during the course of the day they get so many such queries for detailed travel instructions that it is easy to get irritated and shrug them off. Second, an important insight provided to us by our subjects was the sense of security that they would get with such a system. We were informed that even though asking for travel directions from strangers on the street is an option, it exposes the enquirer to criminal elements, who often take advantage of their lack of knowledge and use it to rob them, the activity sometimes resulting into a worse situation such as a murder. This is especially true for first time visitors to the city from remote towns and villages or female citizens traveling at odd hours of the day.

Many people were willing to pay for the call even a small premium over normal charges as they saw value to having this information available to them at all times. Yet a majority of the subjects preferred the advertisement model where an advertisement played in the beginning of the call pays for the entire call. This is understandable, given this segment's high sensitivity to cost. A few users suggested that the advertisement model was better since most of these users primarily have pre-paid SIM cards and often they do not have sufficient balance to make outgoing calls.

Most people were willing to upload content, though a few refused as they were hesitant due to not owning a phone.

Almost everyone preferred the voice based interface over SMS even though we demonstrated speech recognition errors during the study interviews. The primary reason for this cited by them was that many people are either not comfortable using SMS or not comfortable using a mobile phone itself. However, some users who were well versed with SMS preferred it over voice.

In terms of accuracy of returned results, most people asked for full accuracy while a very few were okay with minor mistakes. The need for strong accuracy is driven by the fact that most of these people either use public transport, or use a bicycle or even walk to reach their destination. The cost of a wrong input for them is huge compared to a person driving in his own or rented vehicle. In fact, one of the main reasons for preferring a voice call over asking people for directions was to avoid wrong directions. This is an important feedback since we started with the assumption that we do not need strict controls over the content and the wiki model would work. But the tolerance for incorrect information is low and we need to factor this in.

We also learnt that meta information is as important to Non-ITsavvy users as the landmarks themselves. For instance, in cities, more than the road route from a source to destination, people from the underprivileged segment were more interested in knowing the bus route numbers that could take them to their destination. Road routes serve well those people who travel by their own vehicles but the underprivileged rely primarily on public transportation. Similarly, for rural areas that consist of remotely located towns and villages, what helps the underprivileged people is information regarding modes of transportation (train, bus, boat, cycle-rickshaw, taxi etc.) to take from source to destination, where to make a switch and estimated travel time. Time tables of these public transport mechanisms are another important feature for this segment that can become an essential part of FOLKSOMAPS.

Key Insights : We realized that accuracy of the information is a key requirement and more the meta information available, merrier it would be for these consumers. Also, voice based interface is indeed a preferred mode for this user segment over SMS and the calls to the system should to be free of cost.

C. Results of Survey of ITsavvy subjects

For ITsavvy segment, we conducted the survey with a total of 15 subjects using the web based interface. We also told them that the system has a voice based interface available over a phone call and supporting similar API. The user list consisted primarily of software professionals apart from a couple of businessmen. As expected, the ITsavvy community had significant experience in using the current online maps of cities in Indian metropolitan cities and were able to carefully evaluate our approach, considering the map services that are already operating in metropolitan cities. We try to capture learnings from their feedback.

TABLE IV

SUMMARY OF ITSAVVY USER RESPONSES TO FOLKSOMAPS

Questions	Yes	No
Would you access it for directions?	93%	7%
Prefer FOLKSOMAPS over asking people?	87%	13%
Ready to pay for call (else want ads)?	67%	33%
Will upload content?	87%	13%
Prefer Web for upload?	92%	8%
Results need to be very accurate?	53%	47%

As is evident from the results (Table IV), most survey participants mentioned that they would like to use this service and that it would certainly be more convenient than asking people around in the streets. Interestingly, a bulk of the ITsavvy community did not stress on getting fine-grained direction all the time. They were fine with getting high level directions involving major landmarks.

Most people were fine with paying for the service when offered on phone. Most were also willing to upload content into FOLKSOMAPS but preferred to do so over a web based interface as opposed to SMS or a voice based interface.

Accuracy of responses was important for this segment as well, though not as strongly as for the Non-ITsavvy segment. As discussed earlier, this segment typically used their own vehicles and need high level directions rather than precise route.

A few participants pointed out that while voice-based access is good for interactive session, they would still prefer the content is sent to them via SMS so that they can store it for future access, pointing out that it is easy to forget the directions if you just hear it.

However, this segment had other expectations from the system. Some subjects mentioned that the system should adapt to the user's request and have the ability to produce fine-grained details depending on whether the destination is a popular landmark, or an area or a house in a colony. Few others mentioned that the directions provided by FOLKSOMAPS should take into consideration the amount of knowledge the subject already has about the area, i.e. it should be personalized based upon user profile. One subject mentioned that the current prototype appeared more suitable for driving directions but not for pedestrians.

Just like the Non-ITsavvy community, the ITsavvy community also reflects the need for meta information on such a community-driven map. One subject mentioned that he would be interested in uploading traffic information on routes and would benefit from community uploading such information on the system. A few subjects mentioned that frequent changes in road plans due to constructions should be captured by such a system - thus making it more usable than just getting directions.

Key Insights : While accuracy and convenience score with IT-Savvy population as well, this segment turned out to be more ambitious in terms of deriving benefits from such a system. Based upon the feedback listed above, we learnt that the user interfaces of FOLKSOMAPS *needs to be rich and adaptive to the information needs of the user when considering this community. It also appears to the authors that dynamic and real-time information augmented with traditional services like finding directions and locations would certainly add value to* FOLKSOMAPS.

VIII. DISCUSSION

FOLKSOMAPS we believe, presents a novel approach towards developing a self-sustaining map system, harnessing community input, particularly targeted towards developing countries, where there is a need for such a system.

Reasoners using ontologies consume space and compute power. [6], [7], [8] reports ways through which spatial reasoning can be made faster. This is an issue with FOLKSOMAPS as well. However, FOLKSOMAPS as a system compliments this body of work as its focus is not on improving reasoning capabilities or address scalability needs of underlying ontology reasoners. Rather FOLKSOMAPS can benefit from this body of work by adopting the solutions suggested to improve the computational and reasoning efficiency.

Given their preference towards voice based interface over SMS [9], [10], designing an efficient and user-friendly voice-based user interface for the masses is important for FOLKSOMAPS. For example, while finding directions, user interface should be designed in a way that facilitates users to specify the *level of detail* they are looking for, varying from source to the destination. Voice interface also takes care of the language barrier since content can be delivered in local language as demonstrated in other systems [3]. Voice based interfaces are, however, constrained with the capability of speech recognition technology which is under slow but constant improvement.

Our surveys indicate that most people would like to contribute to FOLKSOMAPS knowledge base. However, in real-life, there are several factors that provide impedence for a user to be an effective information producer. Reasons range from users becoming busy, loosing interest after an initial surge, etc. In a live deployment of FOLKSOMAPS, one needs to also consider pragmatic business models (such as bartering models, advertisements or incentives) using which an in-flow of information can be sustained to keep improving the quality of system responses.

Accuracy of results being of primary concern universally, further research is needed to ensure that various modules of FOLKSOMAPS would guarantee correct and precise results given that the data input by the users is correct in the first place. Also, as the knowledgebase as well as the userbase grows, established scale-up techniques would have to be applied for real life environments.

IX. RELATED WORK

Two research areas that are very relevant for FOLKSOMAPS are the areas of research in use of IT for underprivileged in developing regions and semantic tools for geographic information systems. Apart from these, work in the area of intelligent user interfaces for masses in developing regions is also relevant.

There is a lot of literature on means to harness available information and user generated content [11], [12], [13] to deliver useful services to underprivileged in developing regions. [14], [15] talks about voice-driven technologies (e.g. audio wiki) to capture user content from Non-ITsavvy masses. The Neighbourhood Mapping [16][15] initiative proposes the involvement of school students to gather community input in the context of building maps. The project used PDAs coupled with GPS to build an information repository that could be used of planning purposes. FOLKSOMAPS builds further along this direction and proposes to create alternatives to well established solutions in developed countries, solely through user generated content. Specifically, it focuses on creating a framework (exploiting ontological reasoning), where by geographic information can be captured, enriched, and funneled back to the masses - customized to the needs of developing regions. To the best of our knowledge, we are not aware of any such community-driven map system for developing regions.

There has been considerable work on Place ontologies, retrieval and storage of geographical information using ontologies [8], [17], [18], [6], [7]. For example, [8] talks about limitations of OWL to support spatial reasoning, integrity rules, and proposes a combination of spatial data-based store

[15]http://www.csdms.in/NM/

and ontology-based reasoning to better represent geographic information and resources. [6] further critically evaluates ontology-based approaches towards geographic information retrieval while [7] presents a spatially aware search engine, for semantic interoperability of distributed and heterogeneous GIS on the Internet. In contrast to this literature, FOLKSOMAPS does not focus on improving reasoning capabilities of OWL or address spatial and logical integrity issues of Place ontologies. Rather, we focus on designing concepts of an ontology that is *suitable* for capturing map information from communities, keeping only *logical integrity* in mind, and by exploiting currently standardized semantics of OWL. FOLKSOMAPS in a way is hence complimentary to this body of work and can benefit from it.

A body of research focuses on intelligent user interfaces for developing regions [19], [10], [20] and infrastructures to take IT services to the economically challenged and Non-ITsavvy masses in developing regions [3], [21]. FOLKSOMAPS at its core can certainly benefit from user interface designs to facilitate upload and download of map information. The system, by having multi-modal front-ends fits well with the architectural principles outlined in [3], [21].

X. CONCLUSION

In this paper, we investigated feasibility of a community-driven approach towards creating maps for developing regions. Our system dubbed FOLKSOMAPS, has the potential of providing an effective alternative to expensive map solutions using community input, making map-based services (finding directions, finding locations and landmarks) available to people in developing regions where such services are currently missing. FOLKSOMAPS builds on the current models adopted by users in developing regions and leverages their collective knowledgebase thus overcoming the huge cost barrier in developing such a system. It is specifically designed to provide content that is intuitive for the users.

We conducted a total of about 77 interviews in the process of evaluating a need for such a system and testing our prototype for verifying usability and utility of FOLKSOMAPS. Our surveys suggest that the community is *very receptive towards the concept of a community-driven map* as that alleviates some of the problems (reliance on people, security, inaccurate directions, etc) they face in day-to-day life. We intend to build further upon this system and overcome its current limitations to bring it even closer to users' expectation.

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