Citizen-centric Smart Cities: M-Technology for realizing Smart Participatory Urban Sensing in E-Government

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Abstract:

Cutting-edge approaches for citizen involvement in E-Government urban planning essentially rely on eportals and social network channels, mainly Facebook and Twitter. Based on a conducted field trial and a questionnaire, it can be deduced that current adopted communication channels for citizen involvement are not optimal for bridging the untapped potential of citizen participation in decision-making. This is due to challenges, risks and limitations associated with social networks. In this article, we present a novel participatory urban sensing concept for leveraging personalized, real-time citizen participation in urban planning via a mobile client. The presented concept is fundamentally based on the Location-based Polling and Collaborative Decision Making paradigms, hence realizing bottom-up, citizen-centric approaches for sensing the dynamics of cities through citizen participation.

Keywords-component; *Context-aware Services, Smart Cities, Urban Sensing, Ubiquituous Computing*

I. INTRODUCTION

Cities of the world are encountering an era of extreme urbanization, with more than 50% of the global population now being urban and foresights even expecting this percentage to reach 70% by 2050 [1]. Apparently, the unprecedented rate of population growth in urban areas confronts cities of the world with major demographic challenges. Governments and municipalities of cities are urged with a demanding imperative for finding innovative ways to cope with these challenges, realizing the so-called smart city. There exist different definitions for a smart city; however, Figure 1 shows its fundamental elements and dimensions. From the perspective of this work, we define a smart city as a citizen-centric one in which citizens are at its core, and where advancements in Information and Communication Technology (ICT) are used to leverage citizen participation for urban sensing by ensuring constant exchange of information personalized to the citizens' needs and preferences, so as to mitigate and remedy urban development challenges allowing citizens to shape their own cities. The immense use of mobile devices and personal digital assistants to connect to wireless networks has yet placed governments at the edge of transforming to the so-called Mobile (M-)Governments. M-Government is considered to be a complementary extension to E-Government.

M-Government involves the utilization of all kinds of wireless and mobile technology, services, applications and devices for enhancing services to the E-Government's citizens, employees, businesses and other government agencies [2].

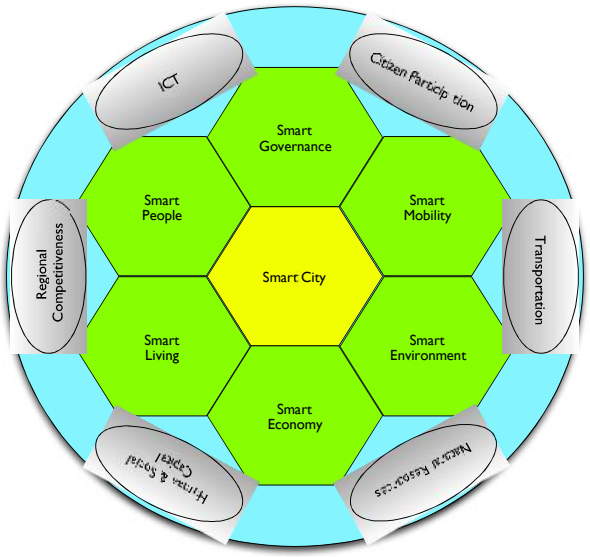

Figure 1: *Dimensions and Fundamentals of a Smart City. The six basic dimensions of a smart city are: Smart Governance, Smart Mobility, Smart Environment, Smart Economy, Smart Living and Smart People. These dimensions are fundamentally based on: ICT, Regional Competitiveness, Transportation, Human and Social Capital, Natural Resources and Participation of Citizens in governmental decision-making.*

Governments and municipalities need to abandon traditional top-down decision-making approaches, and rather consider more grassroots, bottom-up processes for sensing the dynamics of cities based on citizens' participation; participatory urban sensing [3]. However, in an effort to transform to E-Governments, governments and municipalities have embarked on providing information portals, engaging citizens in government decisionmaking as well as providing accessibility to the government itself. Though, this does not implicitly imply realization of a more participatory or collaborative government. In order to enhance citizens' involvement in decision-making, some governments have adopted new communication channels for interacting with citizens. This has substantially been achieved via online social networking channels, mainly Facebook and Twitter [4][5]. Undoubtedly, the involvement of citizens via social networking channels have inspired the involvement of some citizens in governmental decision-making, however, has the impact on citizen participation been substantive or inconsequential? While the opportunities for participation seemed impressive, in the matter of fact citizen participation on average has been lackluster.

In order to address these issues, we have conducted a field trial and an online questionnaire to investigate the usage patterns and reach of social networks among citizens as well as its applicability to be used for citizens' involvement in decision-making. Moreover, within an M-Government scenario, we present a citizen-centric mobile participatory urban sensing application, where citizens are proactively polled by municipalities regarding urban infrastructure issues. The presented application is based on a location tracking mobile client and is realized via a location-based polling and a collaborative decision-making platform.

II. SOCIAL MEDIA AND CITIZENS' INVOLVEMENT IN E-GOVERNMENT

In recent years, some municipal governments have adopted concepts of participatory sensing, where adoption rates of online social networking technology were remarkable. A study conducted in 2009 stated that 34% of US states incorporated an interactive chat feature on their state websites [6]. Furthermore, a 2010 report showed that 63% of the US House of Representative members and 62% of senators used Twitter for interaction with citizens [5]. According to a recent study in 2012, 50 US state websites were examined for using social networks to leverage citizen participation. The study revealed that 68% and 56% used Twitter and Facebook respectively [4]. In an initiative to leverage citizens' participation, the German Chancellor initiated in February 2012 an e-portal called "The Dialogue on Germany's Future" incorporating Twitter for establishing direct communication with citizens. Some government municipalities have also adopted urban sensing applications. For example, the New York City's 'NYC311' service, where citizens can report local city-wide problems.

Owing to the wide adoption of social networking technologies by E-Governments, this raises the question if social networks being the main communication channel is expected to fill the often untapped gap of citizen participation?

A. Usage Patterns and Reach of Social Media

In a conducted field study in 2011, using a demonstrator we have investigated current communication trends. The demonstrator, called the Communication Cockpit [7], provided an integration of various communication services, e.g. real-time messaging threads, VoIP calls, and collaborative real-time document editing. In addition, information services like RSS feeds were injected directly into a running discourse, thus combining communication and information. Initially the 15 female and 45 male participants, aged between 20-55, living in Darmstadt, Berlin (Germany) and Puebla (Mexico) were asked using a questionnaire and a moderated interactive interview. When asked about their subscription to social networks, a majority of 80% used one with an entertainment focus like Facebook, around 41% a career social network like Linked In or Xing and 28% a microblogging site like Twitter. It was striking that Facebook was in general THE synonym for social networks for the majority of the participants, who participate in any social network. However, the results reveal that about 20% of the participants did not use Facebook and almost 10% did not use any social network. In the interviews the participants distrusted social networks due to privacy and security issues. These results, however, coincide with the German social network user statistics, which state that 26% of Internet users in Germany were not subscribed to at least one social network in 2011 [8]. While the aforementioned results show on the one hand that social networking sites already reach quite a high number of a society's population, they meanwhile reveal that almost one third of the population does not participate in a social network at all. Thus, indicating a social media divide among citizens within a city. Therefore, usage of social media in citizens' involvement is expected to lead to segregation, since only a fraction of a society's population is addressed.

Apart from the challenge to overcome digital and social media divide; social networks are associated with challenges and risks that can lead to an unstoppable negative spiral. Such as communication risks, which include internal information leaks to the outside, omission of critical information, misinformation, or over transparency of information [4]. An example of over transparency happened when Lower Saxony police in Germany posted on Facebook detailed data of a suspect for a murderer of a young child. That caused Facebook subscribers to start a hate and lynch campaign versus that person, though the suspect was later declared innocent. While social computing can

be beneficial for E-Government use, the latter example also outlines a possible negative downward spiral leading to a political risk [4]. Therefore, we propose that the usage of social networks for governmental matters need defined steering mechanisms, e.g. a responsible administrative body, as well as defined social etiquettes to reduce operational risks.

In our field trial, we have further investigated the usage patterns of social media. Where participants have been asked about their core activity within social networks, the results are shown in Figure 2. Moreover, within the moderated interviews, some participants emphasized that social networks are rather used for ”chit chat” rather than for personal matters or important discussions. It can be deduced from these results that although social networks seem to be an attractive platform for E-Governments to leverage citizen participation, current social network usage patterns are far less directed towards a serious political discourse, but rather towards quick short information and update purposes amongst the ”friends” list.

Acitivity in social networks (n=51)	
Topic	**Percentage**
Chat	51%
Upload pictures / share photo albums	49%
Organize events	44%
Comment pictures and / or posts from others	42%
Share my current status (what I am currently doing)	36%
Participate in groups	28%
Play games	16%

Figure 2: *Activities carried out in Social Networks*

B. Social Media and Citizen Involvement in decision-making

Does the reach of social media make it a suitable channel for use by E-Governments to involve citizens in decision-making? In order to further investigate citizens’ perception concerning this aspect, we have conducted an Internet-based questionnaire in 2013. Around 90% of the 154 participants were aged between 18-50. Owing to the finding that Facebook is THE synonym for social networks for most of our participants in the initial field trial, the willingness to participate in political or urban planning issues via Facebook was questioned. Surprisingly, as shown in Figure 3, only 31% were willing to, while the majority of 69% were not. The results, however, coincide with the aforementioned field trial results. Even though discussion groups or forums exist within social networks, subscribers do not expect to use them for this purpose. We assume that privacy and security concerns are the main drivers for social networks not being accepted as an exchange platform for serious discussions. Moreover, we have investigated the perception and acquaintance of the participatory e-portal recently launched by the German Chancellor among German citizens. Results show that 71% of the participants did not know about it! Furthermore, when asked about the willingness to participate in the German Chancellor’s e-portal, only 16% were definitely willing to! Results show that citizens have a general apathy in interacting and getting involved with governments, these results coincide with an overall decreasing public interest in participation. As it can be shown

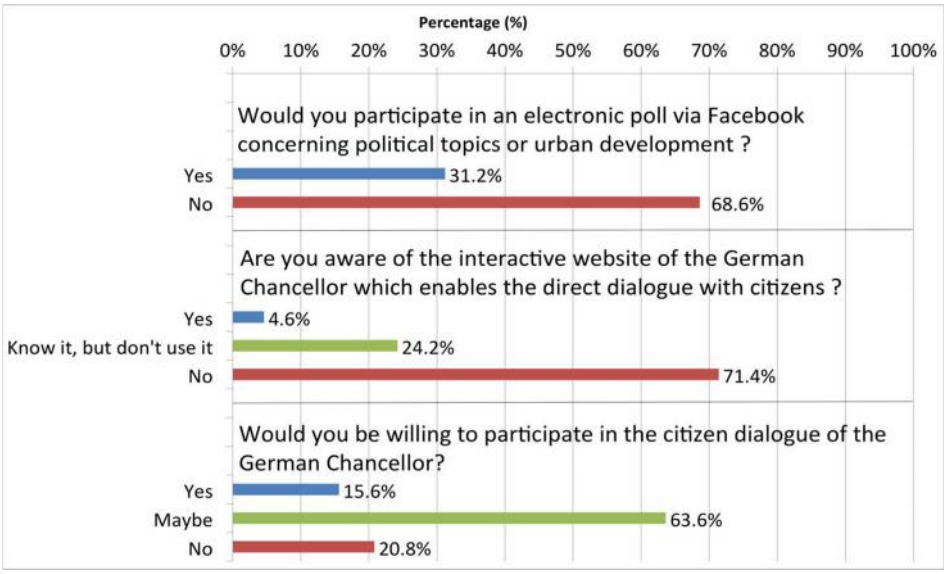

Figure 3: *Online questionnaire results*

from the aforementioned results, the use of social media for promoting citizen involvement in decision-making has inherent challenges and risks. Such challenges include the social media divide among demographically, economically, and socially diverse groups of citizens within a city [9]. Moreover, the current social media usage patterns indicate that citizens do not expect to use them for getting into a discourse with municipalities. Other challenges involve privacy and security concerns. However, the risks include communication, operational and political ones [4].

III. PARTICIPATORY URBAN SENSING CONCEPT

In order for E-Governments to realize participatory urban sensing, they inevitably need to overcome the aforementioned drawbacks of current approaches. The widespread of smartphones among citizens, enable unprecedented distribution channels giving governments a golden opportunity to deliver personalized services how and when citizens want them, utilizing the Mobile (M)-technology [9]. This is essentially realized on top of three unique characteristics; mobility, personalization and wireless; which in the matter of fact contribute to its significance. We believe that utilizing innovative technological methods will re-energize citizen engagement and encourage wider participation in urban sensing. As a result we present a novel mobile participatory urban sensing concept, which strives to bridge the untapped gap between citizen participation and currently existing municipal E-Government approaches to embrace citizens in urban planning processes.

The participatory urban sensing concept, as shown in Figure 4, involves municipalities and E-Governments designing urban planning polls and associating them with certain geographic locations, i.e. geofences, and validity time periods. Citizens are required to register for the service via an application on their mobile clients, which continuously runs in the background. Continuous background tracking of citizens is realized in a smart, novel and battery-efficient manner. Within the validity period of a certain poll, only citizens who come into the vicinity of the urban area under development are polled via their mobile client. All those that have received the poll are then able to collaboratively discuss the poll among each other, exchanging their points of view. After responding to the poll, all responses are then delivered back to the municipal agency. A feedback of the final poll result is then sent upon the

poll's validity time expiry. At the end of a poll, the application on the mobile devices goes passive and is activated once again when a municipality submits a new poll. The application supports several polls concurrently, allowing citizens to participate in different polls with respect to their location.

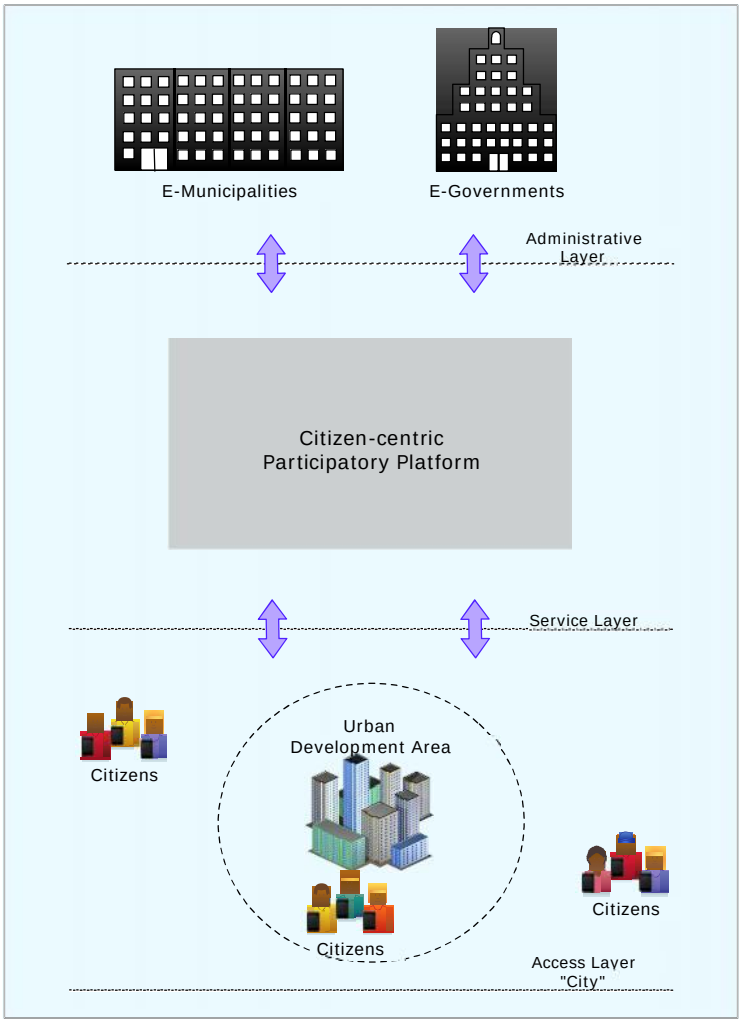

Figure 4: *Participatory Urban Sensing Concept. The Administrative Layer consists of E-Municipalities, EGovernments and Administrative bodies, and is responsible for designing and initiating polls as well as analyzing the responses and providing feedback to citizens. The Service Layer consists of the Citizen-centric Participatory Platform, which is responsible for realization of the participatory urban sensing concept. The Access Layer denotes the city including citizens and urban development sites. A geofence is represented by a circular dotted line and is situated around the urban development site for which the municipality is interested to poll its citizens. Only citizens who enter the geofence receive a poll on their mobile devices.*

The participatory urban sensing concept, realized via the Citizen-centric Participatory Platform, is fundamentally realized on top of two major technical aspects; Location-based Polling and Collaborative Decision Making, and builds upon three main functional blocks; Poll Management, the Positioning Enabler Platform and the Communication Cockpit.

A. Poll Management

The Poll Management component is responsible for handling the polls. The municipal administrative bodies use this component to design urban planning polls, specifying certain context information, e.g. location, time and poll validity duration. The Poll Management component is moreover accountable for collecting the poll responses submitted by citizens. Municipalities could then have access to the poll responses via the Poll Management component.

B. Positioning Enabler Platform for Location-based Services

The Positioning Enabler, shown in Figure 5, is a service platform for providing Location-based Services (LBS) [10][11]. Its main functionality is computing the position of users by exploiting multiple positioning methods and technologies, both device-centric and network-centric, e.g. GPS, Cell-ID, WiFi [12]. The significance of this platform is based on its novel approach for realizing continuous background tracking of mobile devices in a highly battery-efficient manner [10]. Moreover, it analyzes the collected location information in real-time providing services to targets based on their location. According to the LBSs classification presented in [13], the Positioning Enabler is designed to compute the position of single and multitargets in both a reactive as well as a proactive manner, enabling the realization of simple LBSs as well as more complex ones based on background tracking and geofencing. In order not to violate citizens' privacy aspects, municipal bodies do not have access to the Positioning Enabler platform, i.e. to the location information of citizens.

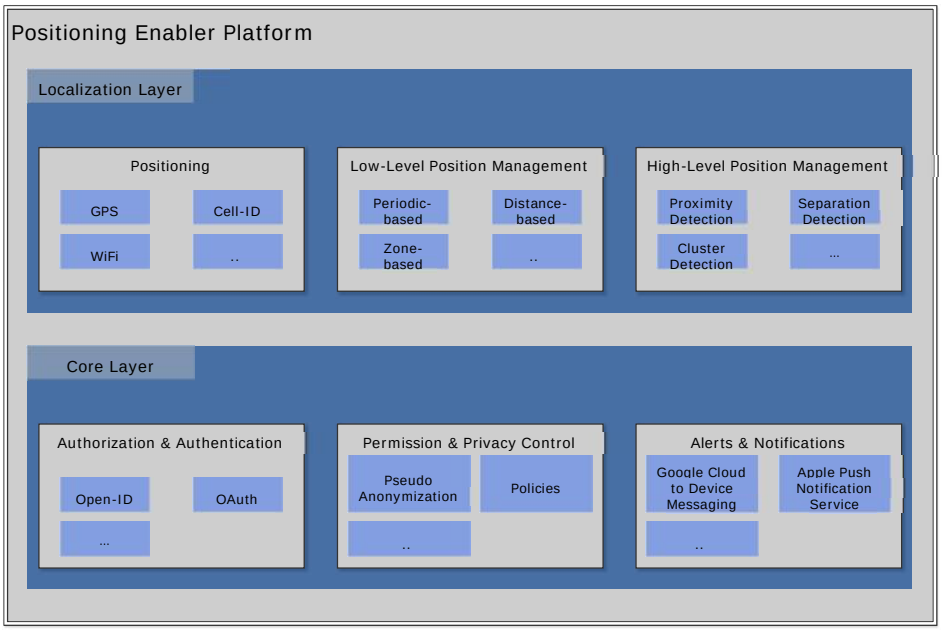

Figure 5: *Positioning Enabler Architecture. It is based on a Core Layer and a Localization Layer. The Core Layer includes: Authorization & Authentication functionality for registering, authorizing and authenticating the user prior to accessing the platform's utilities; Permission and Privacy Control functionality for managing user tracking permissions against 3rd party entities, e.g. municipalities, and for protecting user's privacy; Notification & Alerts functionality for informing the user in case of fulfillment of a certain location event, i.e. in case a user enters a*

geofence. The Localization Layer includes: Positioning functionality for computing the position fixes of users; Low-Level Position Management functionality for managing background tracking and geofencing, thus involves different position update strategies; High-Level Position Management functionality for correlating and processing position data of a single or several users as well as interlinking their positions.

The Positioning Enabler platform is indispensable for citizens to register for the service via their mobile client and get authorized and authenticated. In case of active polls, the platform is essential for continuously positioning and tracking citizens in the background as well as analyzing the collected location information in real-time with respect to the location of urban planning areas with active polls. The Positioning Enabler maintains the geofence of active polls and that of citizens, and is responsible for sending a poll to citizens upon their entry into a geofence of an active poll. The enabler is furthermore responsible for notifying polled citizens with a feedback of the poll result after its validity time expiry.

C. Communication Cockpit for Collaborative Decision-making

The Communication Cockpit [7] is based on the Communication Triangle shown in Figure 6a. Where communication means are provided via social media interaction. Moreover, it is enhanced via information and multimedia services. These two pillars use search and storage as the underlying technical platform. It is enriched via the mass market sphere, e.g. user generated content, video-on-demand and multiplayer gaming, which can be mapped to any specific application scenario, e.g. polling in M-Government. In addition, complementary services and technologies, e.g. location and maps, further enhance the service. Participation and communication within the Communication Cockpit follows a tree discourse [14], which is used to add interaction services to the poll. Such an integrated communication solution provides all essentials for a social and entertainment solution.

The Communication Cockpit, as shown in Figure 6b, can be used to qualitatively enhance the statistical poll results. It provides collaborative discussion via communication flows among the ”citizen crowd”, enriched with key additional multimedia information, such as information about the context of a poll or instructions concerning a poll. Moreover, to omit communication or political risks the citizen crowd dialogue is enhanced by participation of a corresponding administrative body, which steers the discourse as well as monitors the compliance to etiquettes to reach a promising result.

D. Opportunities

The presented participatory sensing concept strives to overcome limitations in existing approaches. This concept enables municipalities to leverage real-time citizen interaction and participation in urban planning by proactively polling citizens via a mobile client based on their geographical location. Moreover, it allows collaborative discussion among citizens as well as between them and municipal administrative bodies regarding the urban planning issue under question. Reaching citizens via their mobile device would overcome the issue of digital divide among citizen groups, as the use of smartphones is becoming ubiquitous with 70% of the US and 60% of the EU mobile devices are smartphones [15]. M-technologies are considered to be more evenly distributed across society when compared to wired technologies [9]. Moreover, mobile devices usually being used by a particular citizen, makes it an appealing venue for delivery of personalized services, e.g. LBSs. On the contrary to existing approaches, in order to participate, citizens are not responsible for searching for the information, they rather proactively get polled if they come within

the vicinity of an urban planning area. Therefore, the participatory urban sensing concept causes minimal overheads to citizens with respect to their participation. Providing feedback in addition to supporting topic-based collaborative discussion fosters the conveniency of citizens' participation in urban planning even further. We believe that the proposed concept will bridge the gap between e-democracy and citizens.

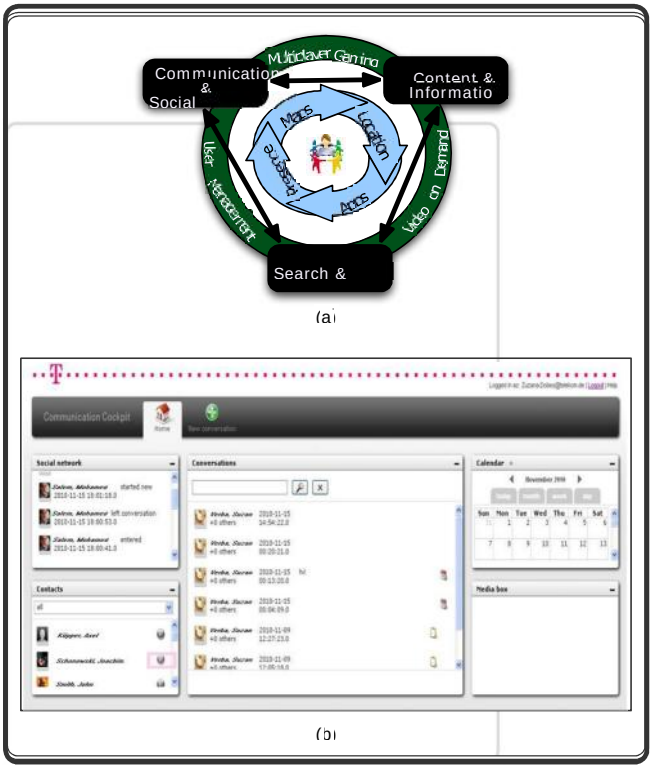

Figure 6: *The Communication Cockpit. (a) Communication Triangle. (b) Screen shot of the Communication Cockpit. The Cockpit integrates a social screen, calendar, contacts, collaborative multi-media storage, e.g. for relevant poll information and the inbox for recent communication flows, e.g. other polls. In addition, it provides VoIP call-conferencing functions, RSS feed integration in flows and collaborative real time document editing.*

IV. CONCEPT SCENARIO AND OUTLOOK

A. Citizen-centric Urban Sensing Scenario

The participatory urban sensing application could be used in various urban planning contexts, e.g. events, new building sites, infrastructure in citywide level. We would like to outline the service usage on a current public transportation example in the city of Berlin. Tram services are historically available in the eastern part of Berlin. Currently Tram line extensions to western parts of the city are discussed by city representatives. Our service could be used to leverage citizen participation in the discussed topic by polling citizens riding on relevant Tram lines regarding their preferences, e.g. whether the Tram extension should follow path A, B, ... or X. The poll results should be provided to participating citizens in real-time. In addition citizens would have the chance to discuss among themselves in a discourse about their preferred choices as well as express their arguments to responsible administrative officials. Who in turn also participate in the discourse, steering the discussion as well as summarizing and providing the final reached

decision. The results would be available to citizens until another E-Government urban planning topic is active, which would then be directly pushed to the application and an additional tab is provided to polled citizens.

B. ***Outlook***

The involvement of citizens in urban planning processes through and with regard to ICT is believed to be one of the major aspects in cities becoming smarter. So far, in contrast to modern society, public institutions and E-Governments are thought of as too slow to keep pace with the rapid evolution in communication trends. Furthermore, in a world where people are ought to be passive with respect to participation, citizens need to be provided with innovative, convenient and appealing methods to facilitate their involvement. We believe that the emergence of the M-technology promotes for a new era of interactive governance through providing of personalized e-services for leveraging participatory urban sensing.

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