Learning, Access, and Mobility (LAMB) for Cultural Heritage Education

Kari Uotila[1,2], Isto Huvila[3], Jari-Pekka Paalassalo[4], Ilkka Helenius[4], Jani Lindholm[4], Minna Lääperi[5], Laura Puolamäki[2], Sirpa Wahlqvist[5]

[1] Muuritutkimus Company, Finland
[2] University of Turku, Finland
[3] Åbo Akademi University, Finland
[4] Turku University of Applied Sciences, Finland
[5] Municipality of Eura, Finland

Abstract

The present paper discusses the results of an R&D project (fi PULU) in south western Finland to develop a general purpose mobile application framework for elementary and grammar schools with a special emphasis on distributed content creation and a usage model anchored in the convergence of pedagogics and location-based cultural heritage information. Since the beginning of 2001, the LAMB project and its predecessors have studied, developed and evaluated several different technological and content design approaches starting from stand-alone applications on palmtop computers, tablet PCs, and smart phones to modern small light-weight portable tablet computers. The technological focus of the effort has been to develop a simple and robust position-aware multiplatform software application based on a simple general purpose data model based on locations. The Java application designed for the LAMB project can be run on diverse portable computers and used by a group of pupils together. Interactions with the application are recorded on the device and the teacher can afterwards evaluate pupil input and device use data. The software is based on freely available and Open Source components. An important aspect of the system is that it can be updated and maintained on site by the local staff without extensive technical knowledge.

***Key words**: mobile computing, information process, mobile learning, information use*

1 Introduction

Advances in mobile computing technology since the mid-1990's have entailed a profusion of academic and commercial projects aiming at producing and deploying handheld guiding and presentation systems for cultural heritage sites. Even if the work done so far has concerned many important issues of mobile technology, presentation and user experience design in a mobile environment, the majority of efforts have focussed on developing working technology prototypes rather than systems with sustainable maintenance models and a long life-cycle of operation. As already recognised in the sense of ubiquitous computing, mobile information systems are not only technical frameworks incorporating location awareness and a user friendly interface for presentation of data using a portable computer.[1] [1]The steps taken this far have been important ones, but not quite enough for exploiting the possibilities of the mobility of *information*. A coming major concern in making an effective and efficient mobile information system is the mobile information and its social dimensions rather than

[1] E.g., K. Cheverst, N. Davies, K. Mitchell, A. Friday, C. Efstratiou, 2000. "Developing a Context-aware electronic Tourist Guide: Some Issues and Experiences," *CHI Letters* 2(1). 17-24; P. Marty, W.B. Rayward, M.B. Twidale, 2003. "Museum Informatics," *ARIST* 37, 259-294; R.A. Grinter, P.M. Aoki, A. Hurst, M.H. Szymanski, J.D. Thornton, A. Woodruff, 2002. "Revisiting the Visit. Understanding How Technology Can Shape the Museum Visit," in E. F. Churchill, J. McCarthy, C. Neuwirth and T. Rodden (Eds.), *The Proceedings of the CSCW 2002 New Orleans, Lousiana, USA* (pp. 146 – 155), New York: ACM Press.

the technical system[2]. Novel technology may function as an attraction and incentive to use a system for a short period of time. In the long run, however, the clear strategic direction, reliability, usability and the accuracy (i.e. that the system provides those services it is expected to provide) do have a significant impact on whether a system is meaningful and successful or not[3].

The findings and insights are based on a project that focuses on archaeological cultural heritage information. The project presentation addresses the issue of how the archaeological heritage information could be delivered with maximum impact in a mobile information environment and more specifically how this delivery could be done in a way that is feasible for information providers (i.e. archaeologists), organisations (museums, cultural heritage administration, tourism enterprises) and end-users (the general public, tourists)[4]. The emphasis of the presented approach is in the optimising the process of delivering suitably situated and contextualised (i.e. accurate) information for the general public instead of barely making existing data (e.g. from books) available. An important premise of the process is that the presented information should be based as largely as possible on the information produced during the first phases of a research project in order to be able to present as timely and new information to the public as possible[5].

This paper introduces a system that has been developed to enhance the process of managing, storing and accessing heterogeneous data with a special emphasis on the mobility of devices and information use. The span of the information process starts from the gathering of original data and ranges to data storage through scientific and administrative uses. The emphasis is on how the production of educational end-user information can be integrated in this information process.

2 Methodology

The methodological basis of the discussed projects has been action research[6]. The researchers have been engaged in developing working prototypes and systems throughout the projects in collaboration with the partners from heritage and tourism institutions. The approach was estimated in the beginning to be the only applicable alternative due to the in progress nature of mobile practises of cultural heritage tourism and related information management research. Traditional life-cycle based development would have been far too inflexible to meet the transient user needs and preferences, dynamic contexts of use, changing requirements and evolution of technologies. The approach has worked relatively well in both projects albeit the frequent practical reconfigurations of the involved project group and the extent of changes made to the technology platform.

3 Early stages of the project

The work for a mobile digital guide began with a white paper on mobile guiding systems on 2001 and continued in practice within the framework of a project aiming at developing a mobile multimedia information system for the Town museum of Naantali, in south western Finland in 2002 and 2003. The project group developed a working prototype of an information system, which offered school pupils and tourists an opportunity to visit excavated sites by using a tablet-PC device as a travel guide. The system was based on a traditional thick client approach due to lack of fast and reliable modestly priced wireless networking technologies capable of covering large areas of urban milieu with a limited amount of hotspots[7].

[2] S. Subramanya, 2006. "Emerging Mobile Technologies and Issues," in Subramanya, S. (Ed.), *International Symposium on Collaborative Technologies and Systems* 2006 (pp. 172). *CTS 2006*, Washington, DC, IEEE Computer Society.

[3] G. Whyte, A. Bytheway, & C. Edwards, 1997. "Understanding User Perceptions of Information Systems Success," *The Journal of Strategic Information Systems* 6(1). 35-68.

[4] R. Skeates, 2000. *Debating Archaeological Heritage*. London, Duckworth.

[5] R. Thomas, 1991. "Drowning in Data? - Publication and Rescue Archaeology in the 1990s," *Antiquity* 65(249) 822-828.

[6] P. Checkland & S. Holwell. 1998. 'Action Research: Its Nature and Validity," *Systemic Practice and Action Research*, 11(1). 9-21.

[7] K. Uotila, H. Lehtonen, C.Tulkki, (Eds.), 2003. *Vallis Gratiae 1443-1648 - Arkeologisia tutkimuksia Naantalissa - Arkeologiska undersökningar i Nådendal*. Kåkenhus -kirjat Vol. 1. Turku, Muuritutkimus, Aboa Vetus –museo and SuVi – projekti; I. Vatanen, K. Uotila, 2003. "The Extended Museum - Augmenting the Sphere of

The second phase of the LAMB (Learning, Access, MoBility) effort, the Medieval Archipelago project started as cooperation between Muuritutkimus, an archaeological research company, and Turku University of Applied Sciences. For the part of Muuritutkimus, the information and concept design of the project was consulted by the first author of this paper from the department of Information Studies at Åbo Akademi University. The development of the software was conducted by the Turku University of Applied Sciences Department of Telecommunication and E-Business. Muuritutkimus was responsible for the design of the basic concept and archaeological expertise. The project was funded by the European Social Fund and the government of the province of Western Finland.

The aim of the Medieval Archipelago project was to produce a pilot of a mobile multimedia information system about the history and archaeology of the Archipelago Sea in Finnish, Swedish and English. The principal target audience of the information system were boaters and sailors, but the system serves also the needs of local tourism, culture, and the direct needs of the local population.

An important aspect of the project was to test the applicability of a GPS-based multimedia presentation in a yacht. The concept of the system was based on the earlier experiences gathered during the Naantali project applied to the specific needs of the yachters. The contents of the multimedia were prepared so that it would be easy to familiarise with the sites from the sea. The basic idea was that the system uses GPS information to identify interesting sites nearby, alert its user and present information in form of maps, text, illustrations, images and three dimensional models. The data storage of the Medieval Archipelago applications was based on a relative simple flat file design, which allowed minimal complexity in the design of the application. The individual media objects were linked together by their relation to a geographical area.

Cultural Heritage Interaction through Information Technology in Medieval Naantali, Finland," in Arnold, D., Chalmers, A., Niccolucci, F., editors. *The Proceedings of the VAST 2003 - Delegate's edition* (pp. 169-172), Brighton, University of Brighton.

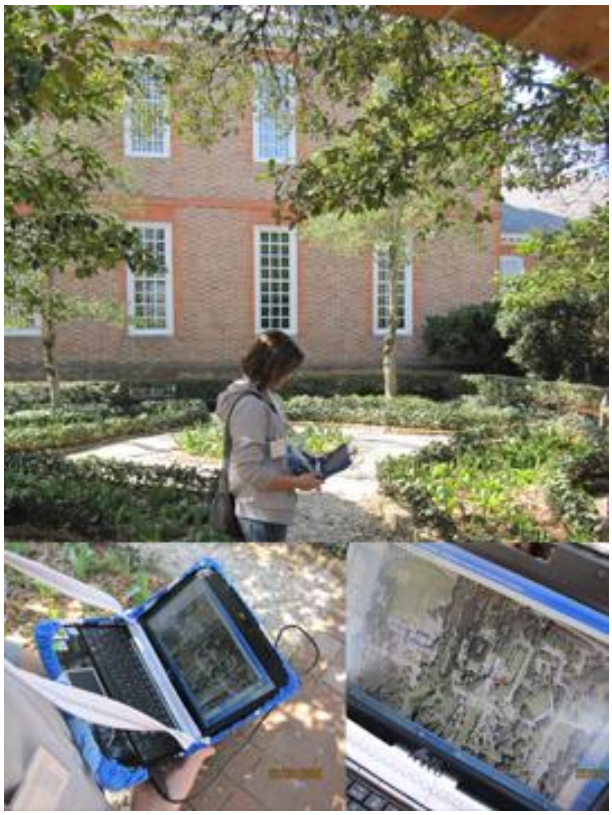

Figure 1. The LAMP (PULU fi.) application in test in the garden of Governors palace Williamsburg spring 2009 (photo Maria & Kari Uotila).

Unlike in Naantali where the information system was intended to be used by school groups walking in the old town area, the version of LAMB system used in Medieval Archipelago project was targeted for a significantly different kind of audience. In the case of Naantali, a portable device with a large display was a priority. In the case of boaters it was assumed on the basis of a pre-study that most of the users would have already either a laptop computer and a fixed GPS navigator on their yacht or a GPS attached mobile phone. Unlike in the Naantali application that was intended to be used on a standardised hardware platform, compatibility with a range of hardware was a priority in the Medieval Archipelago case. According to the expectations of adaptability, the LAMB software was designed to be portable and adaptable from one context of use to another[8]. Even though the Medieval Archipelago system was explicitly targeted to a touristic user group, the conceptual design of the system was kept open enough in

[8] J. Attewell. "Mobile Technologies and Learning: A Technology Update and M-learning Project Summary," *Learning and Skills Network*, 2005.

order to accommodate the use of the same platform in educational settings.

4 The current evolution version

The development of the current evolution version of the LAMB (PULU fi.) system continued in cooperation with Muuritutkimus company, Turku University of Applied Sciences, Åbo Akademi University, University of Turku, Municipality of Eura and Town of Naantali. Project is support financially by The Finnish National Board of Education.

The functional focus was to develop the system further to meet the requirements of Finnish elementary and grammar school curricula. Secondly, the aim was to provide adequate tools and training for individual teachers so that they could themselves produce content for the system. The third aim was to develop a common data repository for all participating actors where they could share their content and construct 'paths', i.e. sequences of visits to individual locations. The focus of the development of the system was on overall performance and flexible usability of the platform in different user defined contexts and in enhancing the user interactions with the system. Medieval Archipelago was based on geographically situated data packages with limited user interaction. The interaction was limited to browsing materials (hypertext, images, video, sound) available on the site. In the new version, there was implemented a functionality that allows pre-programmed interactions at locations and construction of a preferred sequence of visiting the sites. At first the interactions were based on the device in form of location specific questions and instructions. At the moment, the development work is focused on providing possibilities to interact with the programme by moving to different locations.

In comparison to the earlier evolution versions the current LAMB-client is built on a more robust XML-data model, it uses integrated or Bluetooth connected GPS-modules on lightweight Asus 901/1000/R2E models, integrated GPS modules, audio capability and a battery life of approximately from two to five hours. At the time there is three different Asus model in use, two netbooks and one tablet pc. Asus Eee pc 901 and 1000 are under the main focus right now as they offer decent screen size and great usability. 901 offers 9 inch screen and 1000 model 10 inch screen along with integrated audio speakers. Along with lightweight shape, they provide desirable battery life of approximately three hours up to five hours. Both netbooks are provided with Windows XP. Asus R2E tablet pc model offers battery life of approximately two to three hours and is provided with Windows Vista. The R2E model only weights 0,83kg but contains no integrated physical keyboard. 901 model weights only 1,1kg and with 10 inch screen the weight is 1,45kg. The small size and processing power of the device makes it a good technology platform for a mobile guiding system capable of running presentation software and using digital video, audio, images, hypertext and rich features for interacting with its users.

In software architecture our focus has been in maintainability and portability. Java language is well supported on various platforms and operating systems, thus providing a stable foundation for development. Java technology is available in several versions, such as Java SE, Java ME and Java FX. From these, Java SE (Standard Edition) is well established and available on most platforms including smartphones. For these reasons Java SE was chosen for development framework for our application. Only location data must be handled using binary extensions to Java: it is obtained from GPS connection using virtual COM ports over Bluetooth or USB. COM port management needs additional platform-dependent solutions, we have chosen to use rxtx library on Windows. GPS outputs sentences in NMEA format, from which location coordinates are parsed. Coordinate information is then processed utilizing JTS (Java Topology Suite) library, and depending on location, multimedia displays may be triggered. These are implemented using JMF (Java Media Framework). Although portable, the application has been distributed only on two PC platforms: tablet PC and minilaptop (both manufactured by Asus). Technically these two devices are similar, there are no detectable differences running the application. Tablet PC is more weather resistant, but mini laptop has full qwerty keyboard and is thus easier to use. Both devices have display contrast problems at direct sunlight.

Besides the currently supported platforms there has been discussions on using smartphones as the primary delivery platform. The main rationale of smartphones is that the pupils may have a possibility use their own devices. The principal

reason for supporting minilaptops and netbooks instead of smartphones is that at least at the moment there are several problems with using pupils' own devices for school assignments. In Finland, pupils cannot be expected to pay the data communications costs for obligatory schoolwork. Therefore the school has to provide the devices. The second reason is that a slightly larger computer can be used together with a group much better than a small smartphone, which is essentially a personal device. Groupwork was considered important in the context of the socioconstructivistic pedagogic framework assumed in the study[9]. Groupwork enables pupils to combine their personal interests and knowledge in different topics such as history and environment. Similarly it was assumed that some of the technology related barriers could be lifted by manipulating the groups' composition so that there is always someone who is more skilled in using computers.

5 From data to information

The Naantali application was based on a closed architecture, where the new software and content versions were planned to be installed on individual devices in a semi-automated manner. A new version of software and data would have been updated by replacing the older versions of application and data. The content modules (e.g. presentations of individual buildings, objects or historical phenomena) were planned to be tailored for the system. An analysis of the application domain and the potential uses of the system revealed, however, a large number of potential content providers, a need for relatively frequent updates of the content and a need to bring the accumulating research data from on-going excavations and investigations more rapidly into the system than the chosen approach allowed. At the same time, local resources for servicing the system were estimated to be relatively low.

While the work began with the Medieval Archipelago project, the major change in the context was that the application would be unmanaged and maintained by the users themselves. The basic data structure for storing the end-user information was designed to be simple to keep the client software as robust and straightforward to realise and operate as possible, and still expandable for updates and inclusion of future services and information. The content modules were based on geographical locations. A module (i.e. a logical location) comprises hypertext, video, image and audio tracks. The current prototype version is based on an assumption of non-colliding modules, but the strategy of implementing a management for several overlapping locations was taken into consideration in the design.

All of the observations called for a better coordinated approach of managing the contents. Fortunately it was made possible by the decreasing prices of obtaining and providing wireless networking connectivity. The earlier model of content production (where the data was provided in packages together with the software) did not fit in to the new configuration of the system. The individual software versions and content modules were no more independent of each other. There was a clear need of coordinating the linking between the different content modules. Besides the interlinking of the modules, also the linking of the original materials and the content modules became a priority, because a modification in a content module could induce a need to rework other modules. A rapid process of reworking was possible only if all the original material were available.

The initial challenge of enhancing the process of presenting relevant information is in identifying critical differences between initial data and end-user information. Studies on information needs in different groups such as among social scientists[10] , journalists[11] and humanists[12] have shown both the

[9] D.H. Jonassen, 1995. "Supporting Communities of Learners with Technology: A Vision for Integrating Technology with Learning in Schools," *Educational Technology* 35 (4), 60-63; K. Virta, (2005). *Kindergarten, Sloyd and Classroom Teacher Trainees' Self-Directed Learning, Metacognitive Regulation and Web-Based Support*. Turun yliopiston julkaisuja 286. Painosalama Oy. Turku.

[10] M. B. Line, 1969. "Information Requirements in the Social Sciences: Some Preliminary Considerations," *Journal of Librarianship* 1(1) 1-19.

[11] D. Nicholas, H. Martin, 1997. "Assessing Information Needs: A Case Study of Journalists," *Aslib Proceedings* 49(2) 43-52.

[12] S.E. Wiberley Jr., 2003. "A Methodological Approach to Developing Bibliometric Models of Types of Humanities Scholarship," *Library Quarterly* 73(2) 121-159.

variety of information needs, but also the variation of how the information is used. From an information management point of view, the inherent problem with archaeological and other cultural information is the subjectivity and highly contextual nature of the premises of how (often quantitative) source data is used to construct qualitative information[13]. On the other hand, from the end-user point of view, there has been significantly little research on how these applications adapt to the activities and needs of their users. User contexts and needs are not known very well[14], nor are the applications typically, with some exceptions[15], designed for user-created content and functionalities[16].

In order to translate the scholarly observations to interpretations and further to information that is relevant to end-users whether they are tourists in Medieval Archipelago case or pupils in the latest evolution version is a complicated process. Even if an archaeology professional is able to interpret excavation documentation relatively well, the basic data is likely to be highly relevant only to the specialists who are well acquainted with the given material. For a pupil, the central aspect of a site is seldom the specifics of local pottery types or raw measurement data. Even more seldom a pupil is able to contextualise and understand scholarly or technical data. The raw data is not suitable for the general public. Popular information needs to be an aggregate, which is based on several complementary types and sources of information, it is supposed provide a general picture of the past society, it should reflect the estimated interests of visitors and the pedagogical goals of the educational setting. In spite of the differences the scholarly archaeological information shares some qualities with information that is suitable for educational and popular settings. The most profound differences relate to the scale of information, amount of needed context, and the degree of interpretations[17]. The principal difference is in the function of information: whether it is means to educate, inform scientific research or satisfy touristic needs of satisfaction and entertainment.

6 Functions of information

Thinking only of the characteristics of information in the two ends of the information process indicates that the main issue in the management of necessary re-working of content. How this should be done is another question, which can be elaborated further by consideration of the functions of the two categories of information.

The heuristic evaluation and trials of the three systems (in Naantali, on the Archipelago Sea and in Southwestern Finland) revealed several factors that enhance the understanding of the process of delivering information about an archaeological site to the general public. From a practical point of view the information process should produce end-user information that meet the mentioned primary functions efficiently. It would be also desirable that the process is as cumulative as possible, allows extraction of the initial data from the aggregates, results in as little unused information as possible, produces intermediate aggregates that may be used as a basis for further information, and provides flexible support for content and ontology level reinterpretations. Further, when the information is

[13] A. Jones, 2002. *Archaeological Theory and Scientific Practise*. Cambridge, Cambridge University Press.

[14] R. Owen; D. Buhalis & D. Pletinckx, M. Mudge, ; N. Ryan, & R. Scopigno, R., editors. "Visitors' Evaluations of ICTs Used in Cultural Heritage," *Eurographics Association* 2005, 129-136.

[15] e.g. V. Vlahakis; T. Demiris, T. and N. Ioannidis. "Design and Implementation Parameters of Mobile VR/AR Platforms for Cultural Heritage Applications Virtual Reality for Public Consumption," *IEEE Virtual Reality 2004 Workshop*, Chicago IL, 2004, 27. ; N. Correia; L. Alves; H. Correia; L. Romero; C. Morgado; L. Soares; J.C. Cunha; T.R.ao; A.E. Dias & J.A. Jorge. "InStory: A System for Mobile Information Access, Storytelling and Gaming Activities in Physical Spaces ACE '05," *Proceedings of the 2005 ACM SIGCHI International Conference on Advances in Computer Entertainment Technology*, ACM 2005: 102-109.

[16] J. Attewell, & C. Savill-Smith, editors. "Mobile Learning Anytime Everywhere," *A Book of Papers from MLEARN2004*. Learning and Skills Development Agency, 2004. ; J. Attewell, *Mobile Technologies and Learning: A Technology Update and M-learning Project Summary*. Learning and Skills Network, 2005.

[17] S.D. Nolan, 1976. "Tourists' Use and Evaluation of Travel Information Sources: Summary and Conclusions," *Journal of Travel Research*, 14(3) 6-8.; D. Gursoya & K. McCleary, 2004. "An Integrative Model of Tourists' Information Search Behavior," *Annals of Tourism Research* 31(2) 353-373.

used as a part of formal education, it should meet the educational requirements and conform to the pedagogical framework used in the class. A need for adapting a comprehensive framework for mobile pedagogy has been acknowledged as a priority in the literature[18]. In the current project, the framework was based on the concept of meaningful learning developed by Jonassen[19]. The approach focuses on that learners are active, constructive, intentional, cooperative, and they are working on authentic tasks.

The construction of information for the locations varied between the locations where the LAMB project data was gathered. Reflecting the ideal state of conditions with the state of affairs during the excavations in Naantali and the investigations in the area of the Archipelago Sea and southwestern Finland, the acquired spatial information was possible to process in a manner that follows relatively closely the requirements for both scientific and popular needs. In Naantali, the excavation site was measured completely with a total station. The data was passed to AutoCAD for post-processing, to MapInfo for analysis and to 3ds max for modelling and preparation of visualisations. The information from the two later contexts was based on GPS measurements and on the cartographic data acquired from the Finnish National Land Survey. In Kauttua, the information was mostly available from secondary sources. Both processes resulted in only minimal non-used information and the data could be retained in a convertible format throughout the process. The same notions apply to photographs, illustrations and video films, requiring mostly rather simple editing and enhancing.

A central issue of many mobile cultural heritage applications is that interaction and participation in content creation has been limited either by the lack of content creation functionality and documented workflows or by the complexity and cost of required tools[20]. Besides the design of a technology platform, the special emphasis of the LAMB project has been on developing open content creation and delivery model suitable for schools and cultural heritage education. Sharing of content modules is built on an open web based platform. Openness is based on designing and identifying efficient workflows for multiple simultaneous content creators with simple approachable tools, and on educating teachers to produce and share content including interactive quizzes, videos, audio, photos, illustrations, hypertext and geographic information. A webbased collaborative platform for sharing information is currently under development.

7 Conclusions

The findings of the present study indicated that limited knowledge about information and its characteristics in the digital workflow form a significant barrier to developing mobile information infrastructures serving both research, public presentation and educational use of data. By rethinking the work process and focussing on the premises of creating and using information artefacts, it is possible to find new ways to store and manage archaeological information in a more ‘information-oriented‘ manner that takes more precisely into account the behaviour of information producers and the various types of users.

In case of an information system with regularly updated contents, the content production process is not a one-way endeavour. New scholarly information on an archaeological site and information derived from secondary scholarly and technical sources necessitates changes in the information presented to the public audience, but the necessary changes are equally dependent on the existing directly usable information. Therefore, in order to improve the economics of information production, the links between the original scholarly information and end-user information need to be retained in an explicit and workable manner. On the basis of our findings it is important to develop a workflow that retains the link between the original information sources and the end-user

[18] A. Trifonova and M. Ronchetti, 2003. *A General Architecture for M-learning*. Technical Report DIT-03-081, Informatica e Telecomunicazioni, University of Trento. ; A. Brasher; Patrick McAndrew & Staples, M. *Roadmap for Further Research on Pedagogical Issues*, Mobilearn, 2005.

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[20] D. Economou; D. Gavalas; M. Kenteris & G.E. Tsekouras. “Cultural Applications for Mobile Devices: Issues and Requirements for Authoring Tools and Development Platforms,” SIGMOBILE *Mob. Comput. Commun. Rev*., ACM, 2008, 12, 18-33.

information and the different iterations of the information for different audiences, and allows flexible provision of information on multiple mobile and stationary platforms from mobile phones to kiosks and a web site. Existence of a unified framework improves the possibilities to manage data, speeds up the process of producing new information for public audience, makes the entire information process more economical and increases the reliability and coherence of the popular presentation.

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