Testing and Evaluating of Predictive Data Push Technology Framework for Mobile Devices

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Abstract. Current mobile devices with a wireless connectivity are used increasingly as clients of online application servers. Users can use also a increasingly portfolio of hardware and software capabilities to support such connectivity. One problem however still exists in a slow wireless connection in such defined type of using. To allow a work with same comfort as on desktop devices, the prebuffering techniques can be used to reduce a problem of slow downlink. Managing of prebuffering of large data artifacts is made on intelligent decision core based on a current user position computation and future predicted movement computation. All large data artifacts are stored in database along with its position information. The accessing of prebuffered data artifacts on mobile device improve the download speed and reduce a response time needed to view large multimedia data. Testing and evaluating of developed PDPT Framework solution is also presented and discussed along with major tests results.

Keywords: Prebuffering; Response Time; Download Speed; Mobile Device.

1 Introduction

People use their mobile devices mainly to communicate with outer world. They are able to not only make calls or send a text messages, but they can and want to use very sophisticated software running on their mobile devices. Such software can play a role of remote client of some kind of server application. For such kind of connection with a remote world they need to use some type of implemented communication standard like GPRS or WiFi. The connection speed of these standards varies from hundreds of kilobits to several megabits per second. In case of online information systems (e.g. facility management, zoological or botanical gardens, libraries or museums), the WiFi infrastructure network is often used to connect mobile device clients to a server. Unfortunately, the theoretical maximum connection speed is only achievable on laptops where high-quality components are used. The limited connection speed presents a problem for online systems using large artifacts data files. It is not possible to preload these artifacts before the mobile device is used in remote access state.

Every information system with remote mobile clients needs to specify a response time for whole system – mainly for user side. Application cannot wait with response on user request so long, because users are not able to waste their time.

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Nielsen [4] specified this time delay to 10 seconds [5]. During this time the user was focused on the application and was willing to wait for an answer. In newer literature a shorter time is resulted. We used 10 seconds to calculate the maximum possible data size of a file transferred from server to client. We executed a number of tests of real downlink for WiFi network with result of 160 kB/s for actual PDA devices [2], [3], [15]. The client application can download during the 10 second period from 2 to 3 artifacts (real artifacts of building plan were used with an average size of 470 kB). The goal of project is to prebuffer data artifacts to user device before need of them based on localization of user. Information about location is used to determine both an actual and future position of a user [6], [11], [14]. A number of experiments with the information system have been performed and their results suggest that determination of the location should be focused on. The following sections describe also the conceptual and technical details of Predictive Data Push Technology Framework (PDPT).

2 The PDPT Framework

A combination of a predicted user position with prebuffering of data associated with physical locations bears many advantages in increased throughput of mobile devices.

The key advantage of our PDPT solution in compare to [12], [13] is that the location processing, track prediction and cache content management components are situated at server side (Fig. 1). This fact allows for managing many important parameters (e.g. AP info changes, position determination mechanism tuning, artifacts selection evaluation tuning, etc.) online at a PDPT Server.

Position Oriented Database (Wireless Location Architecture - WLA)

If the mobile device knows the position of the stationary device (transmitter), it also knows that its own position is within a range of this location provider. In PDPT framework only the triangulation technique is used due to the sufficient granularity of user position information. Information about the user position are stored in *Position* table. *Locator* table contains info about wireless AP with signal strength which are needed to determine user position. *WiFi_AP, BT_AP* and *GSM_AP* tables contain all necessary info about used wireless base stations. *WLA_data* table contains data artifact along with their position, priority and other metadata.

PDPT Client - Mobile Database Server

The large data artifacts from PDPT Server (WLA_data table) are needed to be presented for user on mobile device. In case of classical online system the data artifacts are downloaded on demand. In case of PDPT solution, the artifacts are preloaded to mobile device cache before user requests (based on user location). Our mobile cache (SQL Server 2005 Mobile Edition was selected for it [7],[8], [16]) contain only one data table *Buffer.* An advantage of using a Microsoft solution is that it takes only small data amount for installation (2,5 MB).

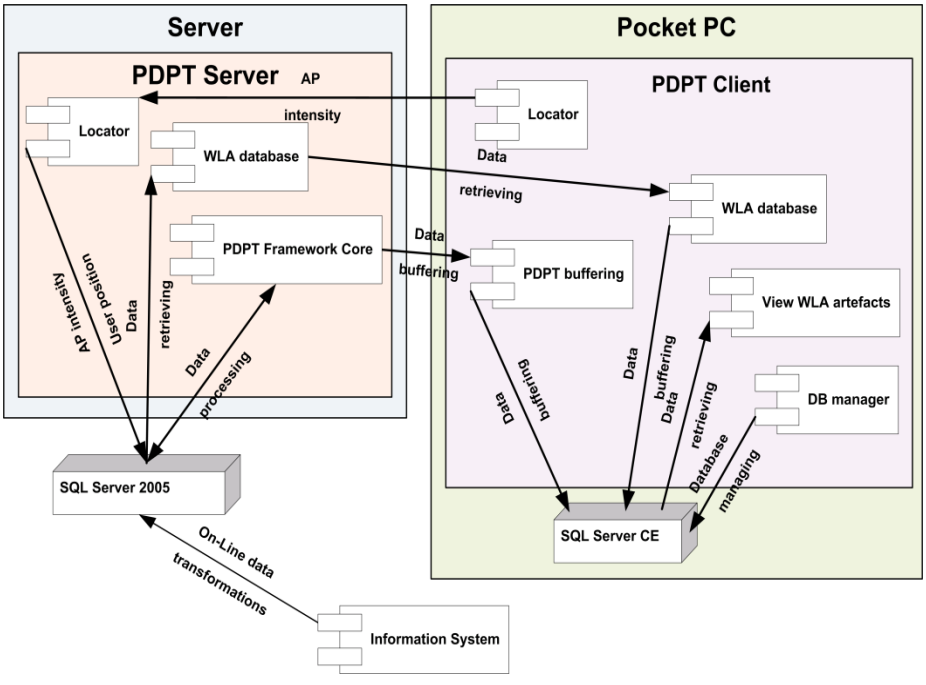

Fig. 1. PDPT architecture – UML design

Data Artifact Creating

Data artifact represents an object in WLA SQL server database with some kind of multimedia file types. Every artifact must have associated with position coordinates in 3D environment (S-JTSK format is used [18]). To manage and work with locations of artifacts, firstly the building floor map is needed to obtain. In most cases the scanned version is adequate. The obtained map needs to be converted to Tagged Image File Format (TIFF). Location coordinates (location, scale, and rotation of a map) for such file must be stored in TFW separate file. Artifacts with position coordinates are stored in WLA database by "WLA Database Artifact Manager" [15].

Data Artifact Managing

The WLA server database manages the artifacts in the context of their location in building environment. The PDPT Core selecting the data to be copied from PDPT server to PDA client by context information (position info).

Created software application called "WLA Data Artifacts Manager" is used to manage the artifacts in WLA database. User can set the priority, location, and other metadata of the artifact. The Manager allows creating a new artifact from multimedia file source, and work with existing artifacts [1], [2], [3], [15].

PDPT Core - Area Definition for Selecting Artifacts to Buffering

The PDPT buffering and predictive PDPT buffering principle consists of several following steps. Firstly the client must activate the PDPT on PDPT Client. This client creates a list of artifacts (PDA buffer image), which are contained in his mobile SQL Server CE database (from previous usage). Server create own list of artifacts (imaginary image of PDA buffer) based on area definition for actual user position and compare it with real PDA buffer image. The area is defined as an object where the user position is in the center of object. The cuboid form (area with a size of 10 x 10 x 3 (high) meters) is used in present time for initial PDPT buffering. The PDPT Core continues in next step with comparing of both images. In case of some difference, the rest artifacts are prebuffered to PDA buffer.

When all artifacts for current user position are in PDA buffer, there is no difference between images. In such case the PDPT Core is going to make a predicted user position. On base of this new predicted user position it makes a new predictive enlarged imaginary image of PDA buffer. The size of this new cuboid is predefined area of size 20 x 20 x 6 meters. The new cuboid has a center in direction of predicted user moving and includes a cuboid area for current position of user. The PDPT Core compares the both new images (imaginary and real PDA buffer) and it will continue with buffering of rest artifacts until they are same.

Creation of an algorithm for dynamic area definition is better in some types of real usage to adapt a system to user needs more flexible in real time.

Accessing the Artifacts in PDPT Client Application

The PDPT Client application realizes thick client and PDPT and Locator modules extension. The data artifact can be viewed from MS SQL CE database to user (immediately with only maximum delay of one second). The PDPT tab presents a way to tune the settings of PDPT Framework. This tab also shows the log info about the prebuffering process and the time of measurement of last artifact loading (“part time”) and also a full time of whole prebuffering process in millisecond resolution.

3 Testing of PDPT Framework

Developed PDPT Framework is mentioned rather than as a whole new way how to work with artifacts, as an addition to classical user access to client application. It cannot be awaited to prebuffer all needed data artifacts at every time. While the proportion of both accesses cannot be measured, both accesses will be tested separately. The whole process of managing with PDPT framework is separated to two ways. In case of ideal PDPT Buffering:

1. PDPT prebuffering of artifacts
2. Selecting of artifacts from combo box menu of client application
3. Viewing of artifacts

In classical case without a use of PDPT Buffering:

1. Selecting of artifacts from combo box menu of client application
2. Downloading of artifacts to PDA Buffer
3. Viewing of artifacts

These several parts are needed to subject of tests, which show a proportion of delay in several mentioned parts. Testing methodology is possible to divide it to two directions: static and dynamic. Static testing mention a way of use a PDA device in one defined position, without any additional moving. While a dynamic testing is performed by a moving of PDA by user. Due to a very bad penetration of WiFi APs in our testing environment in our Campus of Technical University of Ostrava, only a static testing was executed.

3.1 Methodology of Static Testing

For static testing a proportion of quality of PDPT Buffering versus a downloading of artifacts without PDPT were measured. A three function parts was used for testing:

1. PDPT Buffering – self localization
2. Downloading of artifacts from server to PDA Buffer by user
3. Viewing of artifacts from PDA Buffer to display

The last part serves for a testing of viewing speed of artifacts, when the user needs to view them. This delay is a very important value for quality of user work with an application.

Successful of PDPT Buffering is possible to evaluate by a "quality" of prebuffered artifacts in PDA Buffer after PDPT Buffering process. If all artifacts for actual PDA position are after PDPT Buffering process prebuffered in PDA Buffer, we can evaluate such prebuffering as 100% of successful. If some of artifacts are missing, proportion of success is decreasing. The quality of prebuffering is measured as a ratio between real prebuffered artifacts versus awaited sum of artifacts.

As a testing position an expertly defined positions are selected based on number of APs (minimum signal of one AP is needed). For every such test position a sum of artifacts to be presented after prebuffering process is defined. As a self localization a process of determination of actual position of PDA is mentioned.

Quality of PDPT is a percentage value of a structure of artifacts in PDA Buffer, which rate a ration if awaited artifacts were prebuffered at the earliest in compare of all prebuffered artifacts:

$$\text{Quality of PDPT} = \frac{\Sigma \text{ ideal sequence of artifacts}}{\Sigma \text{ real sequence of artifacts}} \times 100 \quad (1)$$

Content of PDPT is a percentage value of really prebuffered awaited artifacts versus all prebuffered artifacts:

$$\text{Content of PDPT} = \frac{\text{number of prebuffered awaited artifacts}}{\text{number of all prebuffered artifacts}} \times 100 \quad (2)$$

Fruitfulness of PDPT is a ratio value in percentage which rate a number of prebuffered awaited artifact were prebuffered in compare to sum of all awaited artifacts:

$$\text{Fruitfulness of PDPT} = \frac{\text{number of prebuffered awaited artifacts}}{\text{sum of all awaited prartifacts}} \times 100 \quad (3)$$

The testing process will consist of several consequence processes as follows: (1) Actual position determination, (2) PDPT Buffering activation, (3) summarization of prebuffered artifacts, time of prebuffering and a size of PDA Buffer database (after finish of prebuffering process), (4) renew of PDA Buffer database (to prevent some old artifacts in Buffer). The testing process will then repeated from (1).

For testing of classical access without a PDPT Framework was a localization process substituted by a selecting of artifacts relevant to selected position (taken from previus testing process). The testing process in this case was as follows: (1) Selecting of artifacts relevant for position, (2) Downloading of all artifacts to PDA Buffer, (3) summarization of downloading time.

3.2 Test Results of Static Testing – PDPT Buffering - Self Localization

Tables (Table 1), (Table 2) show the summary of PDPT Prebuffering test results. Two PDA devices were used. A colored highlight is used for better adjustment of results, where lighter hue present a worse values while darker mean better ones.

Table 1. PDPT Framework – testing results for HTC Universal device

Position	A651			A2			NK2		
time [s]	54,9	62,8	64,7	174,8	152,5	121,9	241,8	246,8	247,3
PDA DB size [kB]	2,06	2,31	2,31	6,81	5,81	4,56	6,75	8,68	8,5
speed [kB/s]	37,5	36,8	35,7	38,95	38,1	37,41	27,92	35,18	34,37
LOCATOR [ΣAP]	3	1	1	2	1	2	1	2	1
awaited artifacts [Σ]	6	6	6	12	12	12	13	13	13
prebuffered artifacts [Σ]	5	6	6	12	11	10	9	11	12
Quality of PDPT [%]	78,9	60	60	54,93	74,16	62,5	56,96	53,23	59,54
Content of PDPT [%]	62,5	66,7	66,7	57,14	64,71	66,67	50	50	60
Fruitfulness of PDPT [%]	**83,3**	**100**	**100**	**100**	**91,67**	**83,33**	**69,23**	**84,62**	**92,31**

In case of first tested device (Table 1), the results provide a very high level of fruitfulness of PDPT Buffering, because al artifacts were prebuffered in most cases. In worst case a 70% was achieved, which is still very good (only one WiFi AP was visible for position determination).

Content of PDA Bufferu after PDPT Buffering is however on lover level, where only 50% was achieved in case of NK2 room testing position.

Quality of PDPT Buffering varies from 53% to 79%, which represents a very successful sequence of prebuffered artifacts.

Fruitfulness of PDPT Buffering is in second case (Table 2) quite lower in compare to previous, but still very good. The worst content of PDA Buffer is same (50%) even in case when two WiFi APs were visible.

Table 2. PDPT Framework – testing results for HTC Roadster device

Position	A651			A2			NK2		
time [s]	53,6	38	49,6	114,4	154,2	174,7	265,9	258,7	260,5
PDA DB size [kB]	2,31	1,62	2,06	4,56	6,06	6,81	8,68	8,5	8,68
speed [kB/s]	43,1	42,7	41,5	39,86	39,31	38,98	32,64	32,86	33,32
LOCATOR [ΣAP]	1	3	2	3	2	1	2	1	2
awaited artifacts [Σ]	6	6	6	12	12	12	13	13	13
prebuffered artifacts [Σ]	6	5	5	12	12	10	11	11	11
Quality of PDPT [%]	60	88,2	83,3	78,79	65	77,46	53,23	56,9	53,23
Content of PDPT [%]	66,7	83,3	62,5	71,43	66,67	50	50	57,89	50
Fruitfulness of PDPT [%]	**100**	**83,3**	**83,3**	**83,33**	**100**	**83,33**	**84,62**	**84,62**	**84,62**

We executed a number of tests for every artifact when viewing them, where we measured a time delay from request to response (artifacts was displayed). An average artifact can be showed in 505 [ms], which present an excellent application response for native image format processing in client application.

3.3 PDPT Testing Evaluation

From PDA user point of view (PDPT Client), the most important parameter for comparing of contribution of PDPT solution is speed of application - response on user's requests. Based on this definition, we can state that a prebuffering though a one artifact which is awaited in PDA Buffer before user request is a huge contribution for application response. PDPT Framework solution is therefore very useful and suitable for stocking in any kind of information systems which manage a position based data artifacts.

4 Conclusions

We develop a PDPT Framework for data artifact prebuffering. Described solution is appropriate to apply in such online information systems, which are targeted to serve with a remote client of such systems. The tests were also evaluated with a suggestion to apply developed PDPT Framework solution in systems which manage with artifacts of size no smaller than 500 kB. In case when smaller artifacts are downloaded a cost of PDPT Framework solution is don't bring any significant improvements. PDPT framework is currently used in another projects of biotelemetrical system to make a patient's life safer and more comfort [9], [10], [17].

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References

1. Krejcar, O.: Problem Solving of Low Data Throughput on Mobile Devices by Artefacts Prebuffering. EURASIP Journal on Wireless Communications and Networking, Article ID 802523, p. 8. (2009)
2. Krejcar, O., Janckulik, D., Motalova, L.: Accessing of Large Multimedia Content on Mobile Devices by Partial Prebuffering Techniques. In: Second Joint IFIP Wireless and Mobile Networking Conference, WMNC 2009. IFIP AICT, vol. 308, pp. 80–91 (2009)
3. Krejcar, O.: PDPT Framework - Building Information System with Wireless Connected Mobile Devices. In: 3rd International Conference on Informatics in Control, Automation and Robotics, ICINCO 2006, Setubal, Portugal, August 01-05, pp. 162–167 (2006)
4. Nielsen, J.: Usability Engineering. Morgan Kaufmann, San Francisco (1994)
5. Haklay, M., Zafiri, A.: Usability engineering for GIS: learning from a screenshot. The Cartographic Journal 45(2), 87–97 (2008)
6. Brida, P., Duha, J., Krasnovsky, M.: On the accuracy of weighted proximity based localization in wireless sensor networks. In: Personal Wireless Communications. IFIP, vol. 245, pp. 423–432 (2007)
7. Arikan, E., Jenq, J.: Microsoft SQL Server interface for mobile devices. In: Proceedings of the 4th International Conference on Cybernetics and Information Technologies, Systems and Applications/5th Int. Conf. on Computing, Communications and Control Technologies, Orlando, FL, USA, July 12-15 (2007)
8. Jewett, M., Lasker, S., Swigart, S.: SQL server everywhere: Just another database? Developer focused from start to finish. DR DOBBS Journal 31(12) (2006)
9. Krejcar, O., Janckulik, D., Motalova, L.: Complex Biomedical System with Biotelemetric Monitoring of Life Functions. In: Proceedings of the IEEE Eurocon 2009, St. Petersburg, Russia, May 18-23, pp. 138–141 (2009)
10. Cerny, M., Penhaker, M.: Biotelemetry. In: 14th Nordic-Baltic Conference an Biomedical Engineering and Medical Physics, IFMBE Proceedings, Riga, Latvia, June 16-20, vol. 20, pp. 405–408 (2008)
11. Liou, C., Cheng, W.: Manifold construction by local neighborhood preservation. In: Ishikawa, M., Doya, K., Miyamoto, H., Yamakawa, T. (eds.) ICONIP 2007, LNCS, vol. 4985, pp. 683–692. Springer, Heidelberg (2008)
12. Brasche, G.P., Fesl, R., Manousek, W., Salmre, I.W.: Location-based caching for mobile devices. In: United States Patent, Microsoft Corporation, Redmond, WA, US (2007)
13. Squibbs, R. F., Cache management in a mobile device. United States Patent, Hewlett-Packard Development Company, L.P., 20040030832 (2004)
14. Brida, P., Majer, N., Duha, J., Cepel, P.: A Novel AoA Positioning Solution for Wireless Ad Hoc Networks Based on Six-Port Technology. In: Wireless and Mobile Networking. IFIP, vol. 308, pp. 208–219 (2009)
15. Krejcar, O.: Localization by Wireless Technologies for Managing of Large Scale Data Artifacts on Mobile Devices. In: Nguyen, N.T., Kowalczyk, R., Chen, S.-M. (eds.) ICCCI 2009. LNCS, vol. 5796, pp. 697–708. Springer, Heidelberg (2009)
16. Dondio, P., Longo, L., Barrett, S.: A translation mechanism for recommendations. In: IFIPTM 2008/Joint iTrust and PST Conference on Privacy, Trust Management and Security Trondheim, Nórway, June 18-20. IFIP, vol. 268, pp. 87–102 (2008)
17. Penhaker, M., Cerny, M., Martinak, L., Spisak, J., Valkova, A.: HomeCare - Smart embedded biotelemetry system. In: World Congress on Medical Physics and Biomedical Engineering, Seoul, South Korea, August 27-September 01, vol. 14, PTS 1-6, pp. 711–714 (2006)
18. Horak, J., Unucka, J., Stromsky, J., Marsik, V., Orlik, A.: TRANSCAT DSS architecture and modelling services. Journal: Control and Cybernetics 35, 47–71 (2006)