The Applicability of Context-based Multicast - A Shopping Centre Scenario

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Abstract. This paper analyzes the applicability of context-based multicast content distribution (CBMCD) on the example of realistic push- and video-based mobile advertising services at a shopping centre. The technical results of the simulation of the service scenario show that CBMCD significantly reduces the number of unicast streams and the total volume of traffic in the network. The results of the financial analysis show that these technical benefits can be translated into considerable financial benefits due to costs savings. Taken together, these results suggest that CBMCD can be an efficient, cost saving network traffic management approach and the basis for lucrative push- services.

Keywords: Context Awareness, Multicast Content Delivery, IP Multicast

1 Introduction

Global mobile data traffic doubles every year between 2009 and 2014 [1]. Mobile data traffic and revenues have become decoupled [14], which forces network operators to make their networks more efficient and to reduce network costs. Multicast content delivery can improve the efficiency of existing networks. With multicast, one data stream is shared by a group of subscribers who receive the same content. This is contrary to unicast content delivery where one data stream is established for each subscriber. Thus, multicast solutions can considerably reduce the network load in scenarios where subscribers receive the same content. The reduction comes at the cost of more limited service, which needs to be shared amongst users. The challenge is therefore for the operator to detect and create content and services that can be shared by several users. One such way is through contextualization of users and the grouping of such users based on their shared interests. The identification of a sufficient number of subscribers who qualify to receive the same content and who thus form a multicast group becomes a prerequisite for making multicast content delivery viable. This prerequisite can be met by acquiring and processing subscribers' context. Context is any information that can be used to characterize the situation of a subscriber that is considered relevant for delivering multicast content [15]. Examples of such context information are situation-specific information (e.g. location, weather, and social relationships) and user profile information (e.g. gender, age, and interests)

Besides the multicast service requirements, there are transmissions requirements. Multicast transmission of data streams, especially in the wireless environment, implies several technology tradeoffs. One of the most important tradeoffs is the power control mechanism of the Radio Interface that might limit the coverage of a radio cell and/or throughput if a multicast transmission is established. Therefore wireless technologies have power control algorithms that control the trade-off between reusing the same channel to deliver data and the cost associated with that. In technologies such as 3GPP MBMS, this factor has been thoroughly studied in [16], [17], [18] and [19]. These studies point towards the need for at least 5 terminals to share the same data stream in order for multicast to be technically advantageous. Furthermore, network equipment needs to support multicast functionalities, which usually do not come as standard part of infrastructure and result in higher costs. Because multicast content delivery costs around three to five times as much as unicast, multicast can only improve network efficiency and be financially profitable if it serves a group of subscribers of a certain size. The research project C-CAST developed a solution that combines group formation based on user context with multicast content distribution, enabling Context-Based Multicast Content Distribution (CBMCD) [20].

This paper analyzes the applicability of CBMCD on the example of a Swiss shopping centre. The main contribution of this paper is twofold: on the one hand, it quantifies potential benefits of CBMCD on the example of a real-world scenario; on the other, it translates these technical results into potential financial benefits. The remainder of this paper is structured as follows. Section 2 describes the research methodology. Section 3 describes the simulated use case scenario. Section 4 presents the results of the simulation and the financial impact calculation. Section 5 concludes with a summary of results, limitations of research, and further research directions.

2 Methodology

This paper follows a two-step approach. First, a use case scenario for CBMCD in a shopping centre is simulated. The simulation shows how real-world service subscribers would behave in such a scenario and how the network would be used to provision the services. Second, we calculate the potential financial benefits due to CBMCD. The simulation results serve as input for the financial impact calculation.

The used simulator is an advanced Geographic Information System (GIS) based on the simulator described in [1]. It takes three vectors as input: network properties, terminals, and services distribution and properties. The first vector includes the location and the capabilities of each base station including coverage and bandwidth capabilities. The second vector contains the location of the terminals. The last vector contains the available services, their average penetration ratios (in relation to the overall population of terminals), and the services' traffic properties. The simulator relates the three vectors by creating a time event in which the terminals are consuming the services in the defined network and calculates the associations of terminals to the base stations by considering the coverage characteristics of the base stations and decisions of the radio resource management. Based on the service penetration ratios, the simulator randomly associates services to terminals. Based on this association, the network load is calculated for each of the base stations, providing a snapshot of the network load. The simulator output includes the service distribution across terminals (calculation based on the average penetration ratios) and the distribution of services per base station (number of terminals and bandwidth used).

Simulation results provide both legacy (unicast bases transmission) and CBMCD views of how services are delivered. CBMCD results are calculated according to what is most technically efficient from the viewpoint of power-control mechanisms in the cell. In this paper, the considered switching factor between unicast and multicast is 5 in accordance to the studies in [16], [17], [18] and [19].

The simulation results allow the calculation of the amount of traffic transferred in the scenario through unicast and multicast. The resulting number of subscribers served via multicast are input to the evaluating of the financial impact of context-based multicast services in the scenario.

3 The Use Case Scenario of the Shopping Arena St. Gallen

Mobile advertising at the Shopping Arena St. Gallen (SASG), Switzerland was chosen as a use case. In 2009, the SASG had 3.7 million visitors and generated a turnover of ~€145 million [5]. With an area of around 32,000sqm for shops and restaurants, the SASG is the largest shopping centre in Eastern Switzerland [2], [5].

The decision to choose mobile advertising in a shopping centre as a use case scenario was motivated by the optimistic predictions for the mobile advertising market (e.g. [9]), the high suitability of shopping centres for both retail-oriented mobile advertising and for location-specific CBMCD. Another reason is the high potential of mobile advertising for all involved players: the shopping mall and its shops, which can access customers in an innovative and personalized way; the customers, who get informed about special offers and coupons; and telco operators, for which it can become a lucrative service.

Shopping centres are well suited for mobile advertising for three reasons. First, shopping centres typically bring together a large number of shops, which wish to advertise in order to draw customers. Second, because people visit shopping centres primarily to do shopping, they are likely to be relatively more inclined to receive mobile ads. Third, shopping centres have per se a high probability to be suitable for multicast, as they attract a lot of people at the same time with high probability that many of them have similar shopping interests.

The values for the three input vectors required for the simulation tool are based on realistic data about available network infrastructure, number and temporal distribution of SASG visitors, and opt-in behaviour for mobile advertising campaigns.

3.1 Network and Terminals Properties

Six cellular base stations were identified nearby the SASG. [3]. Because we propose a future service, we assume that all six base stations feature UMTS. The number of terminals is estimated by drawing upon SASG visitor statistics. Considering 3.7 million visitors and 307 shopping days in 2009 [5], the SASG had an average of 12,052 visitors per day or 72,313 visitors per week, respectively. The varying visitor frequency by day and by time of day is considered by distinguishing two types of days (weekdays and Saturdays) and a period of low and one of high visitor frequency for each type of day. The specific time periods were chosen based on SASG opening hours [2] and SASG visitor statistics [5]. The average number of visitors per week was distributed over the defined time periods assuming that b = 2 * a, b = c, and d = 1.5 * c. The results are shown in Table 1. Each visitor is assumed to have a 3G-capable mobile terminal.[2].The terminals were distributed around the geometric centre of the SASG using a Normal distribution.

Table 1. SASG visitor frequency by type and time of day.

Type of day	Time periods (length)	Average number of visitors per hour
weekdays	9am - 5pm (8 hours) [a]	904
	5pm - 7pm (2 hours) [b]	1,808
Saturdays	9am - 1pm (4 hours) [c]	1,808
	1pm - 5pm (8 hours) [d]	2,712

3.2 Services Distribution and Properties

The services proposed for this scenario are push- and video-based mobile advertising services defined as a number of repeated ad messages for a specific category of products or services. Given that video is among the most preferred mobile advertising media formats [12], video ads of 60 seconds in length that are streamed at 256kbps to a specific target group every hour were chosen as services..Seven shop categories currently present in the SASG were considered as customers: fashion and shoes, groceries, furniture, books, electronics, health, and restaurants [2]. As a result, there are seven different services, each of which serving video ads for products or services in one of the aforementioned categories. To determine the distribution of the services in the total population of SASG visitors, we correspond each service to a specific group of visitors, contingent on gender and age group (grouping of users based on their context information).

Major obstacles for the acceptance of mobile advertising are fear of unsolicited ad messages and lack of perceived control [10]. Thus a SASG visitor needs to opt in to receive mobile ads that are relevant to him or her. We assume that, on average, 25% of all SASG visitors opt in. This is based on previous studies on mobile advertising

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[2] In Q8 2008, mobile penetration in Switzerland was 117.1% [4]. Since we propose a future service, we assume all mobile subscribers have moved to 3G.

[6], [7], [8]. Further, we assume that the portion of visitors who opt in decreases by age. Message frequency is among the most important opt-in contract requirements [13]. We limit the number of received ad messages to one per hour.

Table 2 shows the seven services, gender and age of the corresponding groups of visitors, the size of these groups relative to the total population[4], and the numbers of visitors who are assumed to opt in to receive mobile ads.

Table 2. Services Distribution.

Service	Gender and age of corresponding visitor group	% of total pop.[4]	No. of visitors who opted in		
			904	1808	2712
Fashion and shoes	Females, 20+	40.6%	77	154	232
Groceries	All	100.0%	221	442	663
Furniture	Males, females, 20+	79.0%	154	309	463
Books	Males, females, 20+	79.0%	154	309	463
Electronics	Males, 20+	38.4%	77	154	232
Health	Males, females, 40+	52.4%	70	140	210
Restaurants	All	100.0%	221	442	663

4 Discussion of Results

The purpose of the simulation was to study the impact of using Multicast to distribute content to subscribers based on their context for the scenario described in the previous section. The simulation results provide scenario-based service level information that is further processed in this section into a technical and financial analysis.

4.1 Technical Analysis

Three scenarios were studied corresponding to average visitor rates in a low, medium, and high influx period. Fig. 1 illustrates that far less streams are required in a context-based unicast/multicast service delivery scenario as proposed in this paper compared to the current day scenario where streams are only delivered through unicast streams. From the same figure, it is also clear that as the average number of visitors increases, the number of context-based unicast streams decreases and the number of multicast streams increases. The initial higher value of unicast streams is explained by low penetration of some of the cells. In such cells, there are initially no subscribers. As visitors flux increases, services penetrate all the cells and ultimately all visitors will receive the service through multicast. In an extreme scenario, the number of legacy unicast streams is equal to the number of subscribers. In the proposed solution, the scenario will evolve into a full multicast scenario in which the number of streams is

[4] The gender and age distribution of the SASG visitors is assumed to correspond to that of the overall Swiss population [11].

the number of services times the number of cells (7 * 4 = 28). In such a densely populated area, a legacy unicast service deployment will inevitably lead to a very high blockage probability and consequent loss of revenue due to the inability to serve the service.

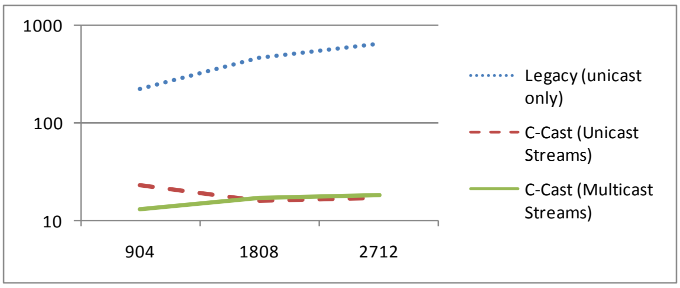

Fig. 1. Number of Streams.

From the simulation, we can also extrapolate the number of bits transferred. We consider that all services consist of a video file of 60 seconds in length streamed at 256kbps. In a legacy scenario (unicast only), the number of transferred bits grows linearly with increasing number of terminals. That growth is insignificant in terms of Unicast plus Multicast streams associated to the CBMCD. In comparison, CBMCD reduces the number of bits transferred by 83.93%, 92.93%, and 94.71% for the low, medium, and high visitor flux periods, respectively. Another interesting result from the simulation is the average group size per cell, which grows linearly from 14 to 34. This result is relevant from a technical viewpoint, since it shows that the switching factor of 5 is quickly overcome.

4.2 Financial Analysis

The previous section has shown that CBMCD significantly reduces the number of unicast streams and the total volume of transmitted bits. This section describes the financial impact of such bandwidth savings.

The videos ads are paid by the advertising shops per each received video. For simplicity, the price charged for each received video is the cost price for a unicast video. Based on [24], the price per video can be calculated to be 11.25 Euro cents.[5] Because all unicast videos are sold at cost price, no financial benefit can be derived from them. Thus, unicast videos are not considered any further. The financial benefit that can be derived from multicast videos depends on three factors: the costs of streaming a multicast video, the number of multicast streams, and the number of visitors who receive a multicast stream. Multicast streaming is around four times as expensive as unicast streaming. Thus, one multicast video costs 45 Euro cents. The number of multicast streams and the number of multicast stream receivers are shown in Table 3. Table 3 also shows the revenues that can be derived from the multicast

[5] 11.25 Euro cents = 60sec video stream * 256kBits/sec * 0.000000715256 Euro cents/bit [14]

videos, the costs incurred by streaming the multicast videos, and the resulting financial benefits.

Table 3. Results of financial analysis.

Population	904	1808	2712
Number of Multicast Streams	13	17	18
Number of Multicast video receivers	201	451	645
Revenues from multicast videos	€ 22.61	€ 50.74	€ 72.56
Costs of multicast videos	€ 5.85	€ 7.65	€ 8.10
Benefit from multicast per hour	€ 16.76	€ 43.09	€ 64.46

The financial benefits shown in Table 3 are only snapshots reflecting one hour in a period with a specific visitor frequency. These snapshots are extrapolated to obtain the financial benefit for one week, month, and year. The financial benefit for one week is calculated by considering length (in hours) and frequencies (five weekdays and one Saturday) of the snapshots (see Table 1). The resulting financial benefits per week, month (week times four), and year (month times twelve) amount to € 7'650, € 30'600, and € 367'195, respectively. In one year, the financial benefit of multicast in the given scenario is € 367'195. This amount contributes to offsetting fixed costs (e.g. for marketing staff and the initial investment required for the multicast setup).

5 Conclusion

This paper has analyzed the applicability of CBMCD on the example of a Swiss shopping centre. Push- and video-based mobile advertising services at this shopping centre were chosen as a use case scenario. The technical results of the simulation of the use case scenario show that CBMCD significantly reduces the number of unicast streams and the total volume of traffic in the network. The results of the financial analysis show that these technical benefits can be translated into considerable financial benefits. Taken together, these results have two main implications: first, locations with similar characteristics as shopping centres can be suitable for lucrative push-CBMCD services; and second, telco operators have reason to consider CBMCD and mobile advertising for tapping new revenues sources.

Even though the use case of the shopping centre in St. Gallen provided a realistic setting for the research, there are limitations that need to be considered and that require further research in order to generate more generalizable results. For example, from the perspective of a telco operator, it might be of interest to have indicators for choosing suitable locations where to offer push-CBMCD services. Such indicators could be the minimum user frequency required at the specific site or the required frequency of push services to achieve savings. Furthermore, the calculation of financial benefits only considered potential revenues and costs of transferred bits. However, CBMCD requires investments and adjustment of the existing infrastructure. Given these limitations, further research is required to investigate potential minimum and maximum values of the considered parameters. Generalized findings can be included in automatic decision-supporting tools for better choice between unicast and multicast in practice.

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