

# Structuring the RCS services on the IMS application layer Part II: Server traffic and configuration comparison

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**Abstract.** This is the second of our two-part paper on structuring the application layer. In the first paper we defined the description and comparison parameters for the application-layer configurations. In the second paper we analyse the impact of each of the services on the server traffic using a real test bed. We find the traffic impact on S-CSCF to be in some cases twice the traffic of basic voice call. Configurations of four different scenarios using the cost function and the parameters are compared. Using the cost function based on the server traffic, the configuration with all the services residing on each AS is shown to be most efficient. We also prove that for each scenario, the traffic on S-CSCF and on the entire configuration for all the analysed configurations is always the same, safe for the traffic on each of ASs.

**Keywords:** RCS, service placement, service triggering, IMS, application server

## 1 INTRODUCTION

The challenge being faced with in structuring the RCS (Rich Communication Suite) services on the IMS (IP Multimedia Subsystem) [1] application layer is how to place a set of services and users on the RCS application servers in a cost-efficient way.

In the first part of our paper [2] we described and compared configuration parameters to be used in structuring the RCS services on the IMS application layer.

In the second part of our paper, we analyse the traffic impact of five services on the server traffic. This is done by using a real test bed. Based on our analysis results, a traffic model enabling service placement for servers is made. By using the model, the configurations for the selected scenarios using the parameters specified in [2] are compared. By optimising the process and using the cost function based on the server traffic, a cost-efficient service placement is proposed.

## 2 A MODEL OF THE SERVICE IMPACT ON THE SERVER TRAFFIC

### 2.1 Test-bed description

In our testing, the test-bed shown in Fig. 1 was used. It consists of a UPSF (User Profile Server Function) database, CSCF (Call Session Control Function) compact server (C-IMS, Compact-IMS) performing the P-CSCF (Proxy-CSCF), I-CSCF (Interrogating-CSCF)

and S-CSCF functions, three application servers (AS1, AS2, AS3), presence server (PS) and users from one to N (UE, User Equipment).

The Iskratel SI3000 software is running on the CSCF compact server and on the application servers. Characteristics of each of the servers and UPSF are: HP Compaq Intel Core 2 CPU 6300, 1.86 GHz processor, Pentium 4, 1 GB RAM with Linux i686 (Carrier Grade Linux 4.0). PS is MobiCents [3]. Connection of each of the servers is 100 Mbit/s FD and they are all connected to the 3Com Switch 3300 XM 10/100 24-port switch. The Mercurio Bronze [4] and Boghe [5] terminals and the SIPp traffic generator [6] are used as users (UE, User Equipment).

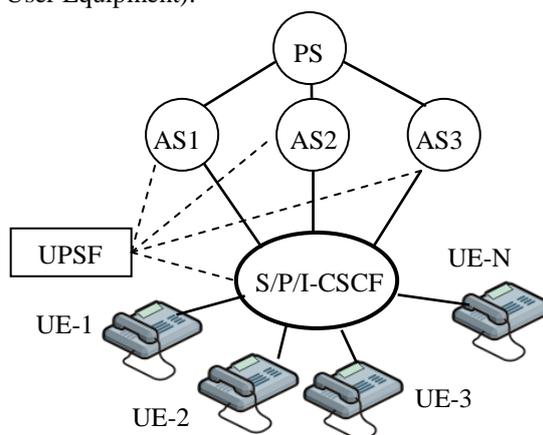


Figure 1. The test-bed setup

## 2.2 Characteristics of analysing the service impact on the traffic

We first analysed a set of five services placed into an environment with three application servers. The services were placed on S-CSCF and on one or two ASs. In case of two ASs only the basic call and IM are possible. We analysed the compact version of CSCF, as we were interested only in the signalling traffic and impact of the service traffic on S-CSCF and ASs. In our analysis the traffic was divided into individual segments, i.e. the traffic of each service was analysed separately.

Other simplifications and particularities of our analysis are:

- For the basic call (BC), TIP/OIP services are assumed to be used.
- For the basic voice call, the minimum number of messages and additional options (PRACK, 183) are taken into account.
- For CDIV only CFU is analysed.
- When analysing the IM service, the page mode is taken into account, by using the SIP MESSAGE method.
- For subscribing, the presence service and registration are taken into account.
- For the presence service, both possibilities for PS (PS is outside AS, PS is part of AS) are taken into account in the model.

## 2.3 Detailed analysis of the traffic characteristics

### 2.3.1 Basic call

In our basic voice-call traffic model, the call with no additional options is used. For the basic voice call with the PRACK additional option, there are two extra sets for sending the PRACK messages to the basic call (BC). Fig. 2 shows the basic call on S-CSCF using the additional option of exchanging PRACK and 183.

### 2.3.1 CDIV

In case of CDIV (CDIV-CFU), the messages are the same as to those of the basic voice call, except that for CDIV from AS1 towards the user the additional message 181 (Call Forwarding) is sent, to notify that the communication has been forwarded. The traffic model is defined as the difference to the traffic model for the basic call (defined as BC).

### 2.3.2 CAT

When using CAT, the messages are the same as those of the basic voice call. The difference is that for CAT the call is directed from AS1 toward S-CSCF and user B. When the information about ringing is received from user B, the tone control as desired by the user is requested by MRF (Media Resource Function). The traffic model is defined as the difference to the traffic model for the basic call (defined as BC). When using S-CSCF, additional INVITE is sent from S-CSCF to

MRF. When using S-CSCF and AS1, an additional INVITE is sent from AS1 to S-CSCF and further by the H.248 protocol to MS (Media Server).

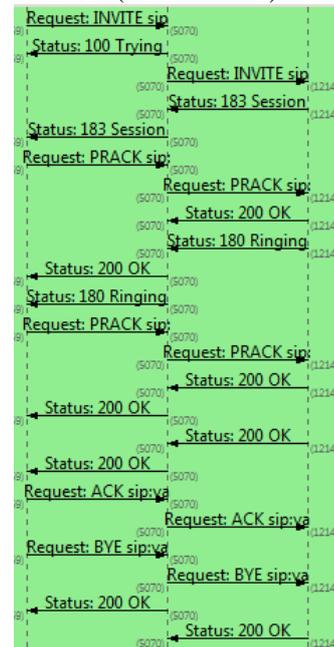


Figure 2. Basic voice call on S-CSCF with an additional option for exchanging PRACK and 183

### 2.3.3 IM

When using IM, the MESSAGE is sent. It is confirmed by 200 on user B. Fig. 3 shows an example of IM execution for the case of S-CSCF, AS1 and AS2.



Figure 3. IM (page mode) between user A, S-CSCF, AS1, AS2 and user B

### 2.3.4 Presence

User A (the source of presence) publishes each state change with the PUBLISH message and the event package *Event: presence* in case of presence. The message goes from S-CSCF to AS1 and PS. Each user B (watcher) is informed about the state change by a NOTIFY message and the event package *Event: presence*. The message goes from PS, AS1, and S-CSCF to user B. Fig. 4 shows the message exchange at the interface between S-CSCF and AS (which contains PS) for the two-watcher case. The presence source sends PUBLISH, which is confirmed by 200.

AS1 (PS) then sends two messages NOTIFY, which are confirmed by 200. To analyse the traffic, PUBLISH and NOTIFY must be taken into account. The traffic due NOTIFY depends on the number of the watchers (W).

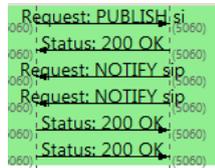


Figure 4. Publishing the states of the presence service between S-CSCF and AS (which includes also PS), when there are two users subscribed on receiving information on publish

### 2.3.5 Registration

To register, the REGISTER message is sent to S-CSCF. It is followed by authentication to UPSF with the MAR/MAA (Multimedia Auth Request/Answer) message and is confirmed by 401. In the second part of registration another REGISTER is sent. It is followed by the exchange of SAR/SAA (Server Assignment Request/Answer) and confirmed by 200. To re-register and de-register, the procedure is the same as for registration, safe for confirmation which is made only by 200, and there is no access to UPSF. The registration procedure in shown in Fig. 5.

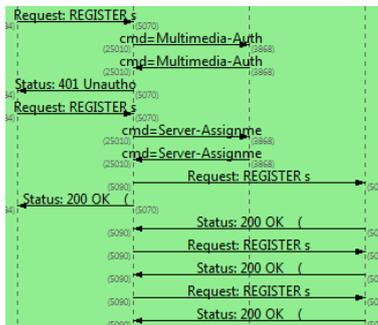


Figure 5. User registration from S-CSCF (REGISTER, 401, REGISTER, 200) to UPSF (MAR, MAA, SAR, SAA) and further to AS (REGISTER, 200), where there are three service groups (G=3)

When using AS1, REGISTER is sent to AS1 and is confirmed by 200. There are as many requirements for registration as there are iFC records in the database for AS. In Fig. 5, there are three service groups (G=3) on AS which makes three iFC records in the UPSF database. Such an example is configuration K1 described in [2], where the first iFC record is for INVITE (TIP/OIP, CDIV, CAT), the second for MESSAGE (IM) and the third for PUBLISH and SUBSCRIBE (Presence).

### 2.3.6 Subscription

To subscribe the user sends the SUBSCRIBE message. Subscribing for the presence service consists of subscribing to the state changes with the event package

*Event: presence* and subscribing to receiving the information about watchers with the event package *Event: presence.winfo*. To register, the user subscribes to the registration state with the event package *Event: reg*. Fig. 6 shows subscribing with the SUBSCRIBE message for the event package *Event: presence*. Subscribing is made on S-CSCF, AS1 and external PS. SUBSCRIBE is confirmed by 200. NOTIFY then sends the information about the watchers. SUBSCRIBE is sent to each subscriber present in the contacts.



Figure 6. Subscribing using SUBSCRIBE for *Event: presence* which is sent for each user in the contacts (from S-CSCF, AS1, to external PS)

The traffic is analysed with regard to SUBSCRIBE and NOTIFY. In case of registration and event package *Event: reg* the traffic is only on S-CSCF. In case of subscribing for presence and event package *Event: presence.winfo* user A sends a request for subscribing. Subscribing is confirmed by 200 and then by NOTIFY. In case of subscribing for presence and event package *Event: presence*, user A sends one request for each user B that is present in the contacts (C: number of contacts). Subscribing is confirmed by 200 and then by NOTIFY.

## 2.4 Server impact on the traffic from given services

### 2.4.1 Traffic with only S-CSCF in the chain

Table 1. The number of messages with only S-CSCF in the chain (on S-CSCF) (S: number of messages)

Seja	S (to)	S (from)	S
<b>REG</b>	4	4	8
<b>de-REG, re-REG</b>	1	1	2
<b>BC</b>	6	7	13
<b>BC+183</b>	BC+1	BC+1	BC+2
<b>BC+PRACK</b>	BC+4	BC+4	BC+8
<b>BC+183+ PRACK</b>	11	12	23
<b>CAT, CDIV</b>	BC	BC+1	BC+1
<b>IM</b>	1	1	2

Our analysis of the traffic for the services executed only on S-CSCF is given in Table 1. For each service, the number of the messages to and from the servers and the total number of all the messages are given. BC is the number of the messages for the basic call. The basic call is further expanded by sending PRACK and 183 as an additional option.

It is seen that the traffic impact due to registration (8) is more than half the basic-call (13) traffic, and that the

basic-call traffic with additional options (PRACK, 183) is twice (26) the traffic with no additional options (13).

#### 2.4.2 Traffic with S-CSCF and one AS in the chain

Table 2: The number of messages where there are S-CSCF and AS1 in the chain (S: number of messages, G: number of groups - number of iFC records for user for AS, A: number of AS on which there are services for user, C: number of contacts)

Service	Server	S (to)	S (from)	S
<b>REG</b>	S-CSCF	$4+1*G*A$	$4+1*G*A$	$8+2*G*A$
	AS1	$1*G$	$1*G$	$2*G$
<b>re-REG de-REG</b>	S-CSCF	1	1	$2+2*G*A$
	AS1	$1*G$	$1*G$	$2*G$
<b>SUBS</b>	S-CSCF	$6+4*C*A$	$6+4*C*A$	$12+8*C*A$
	AS1 brez PS	$4+4*C$	$4+4*C$	$8+8*C$
	AS1 + PS	$2+2*C$	$2+2*C$	$4+4*C$
<b>BC</b>	S-CSCF	13	13	26
	AS1	6	7	13
<b>BC+183</b>	S-CSCF	BC+2	BC+2	BC+4
	AS1	BC+1	BC+1	BC+2
<b>BC+PRACK</b>	S-CSCF	BC+8	BC+8	BC+16
	AS1	BC+4	BC+4	BC+8
<b>CDIV</b>	S-CSCF	14	14	28
	AS1	BC+1	BC+1	BC+2
<b>CAT</b>	S-CSCF	6	8	14
	AS1	BC	BC+1	BC+1
<b>IM</b>	S-CSCF	4	4	8
	AS1	2	2	4
<b>Pres</b>	S-CSCF	$2+2*W$	$2+2*W$	$4+4*W$
	AS1 brez PS	$2+2*W$	$2+2*W$	$4+4*W$
	AS1+PS	$1+1*W$	$1+1*W$	$2+2*W$

For the services executed on S-CSCF and on one AS (AS1), the traffic analysis is shown in Table 2. BC is the number of messages for the basic call, C is the number of contacts in the contact, A the number of ASs on which there are services for the user, and G the number of groups for each AS (number of iFC records for the user). In addition to the messages for S-CSCF (total 8), pairs of the messages (REGISTER, 200) are also taken into account for each record iFC (G: the number of service groups), for each of the application servers (A: number of AS) and for registration.

The analysis shows that the traffic on S-CSCF due to IM (8) can be one-third of the traffic for the basic call with no additional options (26). The traffic due to both subscribing and registration ( $10+20=30$ ) is higher than the traffic for the basic call (26). The traffic for the basic call with additional options (PRACK, 183) is almost twice (BC+20) the traffic for the basic call with no additional options (BC=26). It is seen that the impact of

the traffic services based on the voice call (CDIV, CAT), is similar to the impact of the basic voice-call (BC).

The traffic due to the presence can soon produce more traffic than the basic call. If there are five watchers, which means that on S-CSCF and AS1 there are 24 messages ( $4+4*5$ ), on S-CSCF it is almost the same as for the basic call (26) and twice that on AS1 (13). In case of eight watchers, the traffic on S-CSCF ( $4+4*8=36$ ) due to the presence is the same as the traffic for the basic call in case of two ASs (37).

#### 2.4.3 Traffic with S-CSCF and two ASs in the chain

Table 3: The number of messages if there are S-CSCF, AS1 and AS2 in the chain (S: number of messages)

Session	Server	S (to)	S (from)	S
<b>BC</b>	S-CSCF	19	18	37
	AS1+AS2	11	13	24
<b>BC+183</b>	S-CSCF	BC+3	BC+3	BC+6
	AS1+AS2	BC+2	BC+2	BC+4
<b>BC+PRACK</b>	S-CSCF	BC+12	BC+12	BC+24
	AS1+AS2	BC+8	BC+8	BC+16
<b>IM</b>	S-CSCF	6	6	12
	AS1+AS2	4	4	8

Table 3 shows the traffic when the services are executed on S-CSCF and two ASs (AS1, AS2). It is also shown that the number of messages on S-CSCF (BC+30) for the basic call with additional options (PRACK, 183) is almost twice the traffic for the basic call with no additional options (BC=37). The traffic for IM in case of two ASs in the chain (12) is almost the same as the traffic for the basic call if there is only S-CSCF (13) in the chain. In case of the basic call, each server in the chain doubles the traffic (S-CSCF: 13, one AS: 26, two ASs: 37).

### 3 CONFIGURATION COMPARISON AND OPTIMAL CONFIGURATION SELECTION

The various configurations [2] were compared by using the time parameters in a real environment. A simulated comparison using the cost function and description parameters [2] was also performed. Our emphasis was laid on on the server traffic. Scenarios were compared with the most basic RCS services, i.e. the basic voice call with no additional options (OIP/TIP) and IM, plus registration.

#### 3.1 Time-parameters comparison

To compare the time parameters given in Table 4, we performed 1.000 measurements with 4 to 12 users (using SIPp). Besides the time parameters (given in ms with a standard deviation) defined in [2], two other time parameters were also measured. The first is the delay between sending INVITE and receiving 100 (on user A), and the second is the delay at session connection

between sending 200 and receiving ACK (on user B). For the basic voice call and IM, the session is chained across two ASs for K1-K4.

Table 4. Comparison of the time parameters (in ms)

Parameter	Start-stop	K0	Stdv	K1-K4	Stdv
SRD	INVITE-180	72	1	316	12
INVITE-100	INVITE-100	14	11	10	2
200-ACK	200-ACK	20	0	84	7
SDD	BYE-200	19	1	11	3
SMD	MESS-200	54	0	313	13
RRD1	REG-401	56	1	55	9
RRD2	REG-200	95	7	101	14
RRD	REG-200	148	18	152	26
re-REG	REG-200	78	13	66	5
de-REG	REG-200	100	14	115	14

### 3.2 Selected scenarios of the given configurations

Table 5. Scenarios used to compare the different configurations (number of changes for a busy hour)

Scenario	BC	IM	Reg	Name of scenario
SC1	4	8	1	Avg
SC2	4	12	1	AvgIM
SC3	2	2	4	MinReg
SC4	4	1	-	Bc

Four scenarios were used with the traffic data for the busy hour (see Table 5). Four voice calls were assumed for the basic call (0.1 Erl), 1-12 SMS for IM (according to the results given in [4]), and 0-4 registrations. Ten measurements were simulated for 120 to 1.200 users.

### 3.3 The cost function

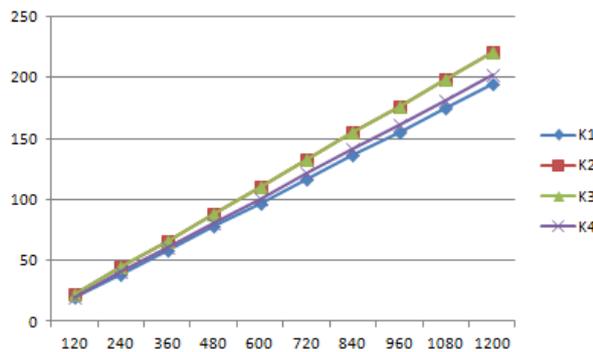


Figure 7. Cost function for SC1(Avg) (in 1.000) as a function of the number of users (optimal choice: K1)

Our calculation of the cost function (C1) was based on the traffic on the servers. C1 is the sum of the traffic on S-CSCF (TS) and the maximum traffic on all ASs (TASmax) for the busy hour;  $C1=TS+TASmax$ .

Fig. 7 shows C1 (the number of the messages in the busy hour in 1.000) for SC1 (Avg) as a function of the number of users. As seen, the function is linear. C1 is minimal for K1 and a little less for K4. The ratio C1 between K2 and K1, and C1 between K3 and K1 is 1.14, and between K4 and K1 it is 1.04. The same

applies for C1 in case of SC3 (MinReg), given in Fig. 8. In this case, C1 is minimal for K1 as well as for K4. The ratio of C1 for K2 and K3 remains the same (1.14). The difference in case of K1 for 1.200 subscribers is the value of C1 (194.400 signals for SC1 against 135.600 for SC3).

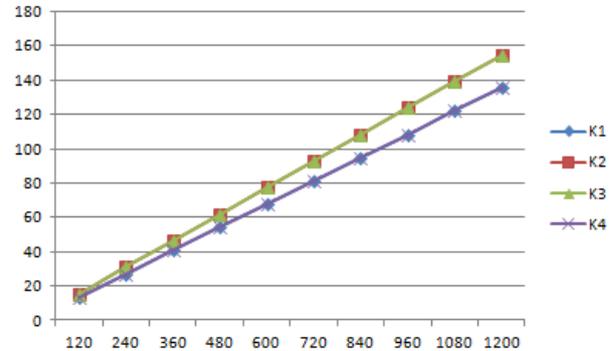


Figure 8. Cost function for SC3 (MinReg) (in 1.000) as a function of the number of users (efficient choice: K1, K4)

### 3.4 Configuration comparison using description parameters

Table 6. Comparison using the description parameters for SC1 (the parameters that vary among the configurations are shaded)

Parameter	K0	K1	K2	K3	K4
NUTS	42	134	134	134	134
NUTC	42	218	218	218	218
NUTASmax	0	28	50	50	34
NUTASavg	0	28	28	28	28
TASmm	-	1	-	-	1.36
NSSRD	1	4.39	4.39	4.39	4.39
NSTASavg	0	0.21	0.21	0.21	0.21
NSTASmax	0	0.21	0.37	0.37	0.25
NSTASall	0	1.63	1.63	1.63	1.63

Table 7. Normed traffic on the user on the S-CSCF (NUTS), configuration (NUTC) and maximally loaded AS (TASmax) (the efficient choices are shaded)

SC	K0	K1	K2	K3	K4
SC1	42	134/218/28	134/218/50	134/218/50	134/218/34
SC2	46	158/258/33	158/258/50	158/258/50	158/258/50
SC3	47	97/145/16	97/145/32	97/145/32	97/145/16
SC4	27	80/132/17	80/132/48	80/132/48	80/132/24

The configurations for SC1 are compared (see Table 6). These are normed data on the user. The traffic on S-CSCF (NUTS), on the configuration (NUTC) and average traffic on AS (NUTASavg) for all the configurations (K1-K4) is the same. The delay ratio on the INVITE path (NSSRD) is 4.39. AS is loaded on average by a factor 0.21 with regard to S-CSCF (NSTASavg). The differences are at the maximum traffic on AS (NUTASmax) and for the traffic ratio between ASs (TASmm).

In Table 7, configurations of each of the four scenarios are compared. For K0, NUTS=NUTC. The efficient choices are shaded. In all the cases, the most efficient choice is K1. The efficient choice for SC3 is also K4. K4 for SC2, however, means also TASmax.

### 3.5 Service placement proposal

We assume all the ASs have the same traffic capacity (TASmax), safe for S-CSCF whose capacity is greater. It can be seen that the traffic on S-CSCF (TS) and on the entire configuration (TC) is the same for the given scenario. The main difference is in different traffics on each AS (TASmax, TASmm).

The most efficient configuration in terms of C1 is K1. It is scalable and is efficient also for a greater number of users. The condition is that on every AS the number of the users must be the same and that the traffic capacity of AS regarding the S-CSCF is appropriate. According to Table 6, the traffic ratio between AS with the maximum traffic and the traffic on S-CSCF (NSTASmax) is 0.21 for K1 (in general it varies between 0.21 and 0.37).

Assuming the baseline scenario to be SC1 and the basic (efficient) configuration K1, other scenarios and configurations are compared according to SC1 for K1. The relative ratio is shown in Table 8. From K1 to K4 the traffic ratio at S-CSCF is from 0.60 to 1.18, and for the entire configuration it is from 0.99 to 1.93. For different scenarios and thus for the minimum and maximum traffic, the deviation factor is almost 2 for both cases. The same applies for the maximum traffic on AS. The traffic fluctuation on AS (TASmax) is shown for the traffic on S-CSCF (TS) for different scenarios. For K1 the traffic fluctuation is in the range from 0.12 to 0.37.

Table 8. The relative ratio between the traffic on S-CSCF (ts), configuration (tc) and AS with the maximum traffic (tmax) and the traffic on S-CSCF (ts) in case of SC1 for K1 (the lowest values are shaded)

	K0	K1-K4		K1	K2	K3	K4
	ts	ts	tc	tmax	tmax	tmax	tmax
SC1	0.31	<b>1.00</b>	1.63	0.21	0.37	0.37	0.25
SC2	0.34	1.18	1.93	0.25	0.37	0.37	0.37
SC3	0.35	0.72	1.08	0.12	0.24	0.24	0.12
SC4	0.20	0.60	0.99	0.13	0.36	0.36	0.18

In Table 8 it is shown that configuration K4 is optimal, too. Its advantage are its voice-based services which are separated (AS1, AS2) from the RCS-based services (AS3). If there is no scenario SC2 (with the maximum number of SMSs/MMSs), the maximum traffic on AS for K4 (0.25) is by less than 20% higher than the traffic on AS for K1 (0.21).

## 4 CONCLUSION

In the second part of our paper on structuring the application layer we propose a model of the service impact on the server traffic. The presented configurations are compared using the cost function and parameters for four different behavior scenarios on the basis of which the service placement is proposed.

Our analysis of the service impact on the server shows that some of the traffic impacts on S-CSCF can be almost twice the impact of the basic call when no additional options are used. The results of our analysis of the configurations for the four scenarios using the basic call, IM and registration prove that the total traffic for S-CSCF and the entire configuration for each scenario is the same, different for the traffic for each of ASs. The traffic on ASs is an important data when calculating the cost function. This imposes the dilemma of how the cost function should be upgraded.

The most efficient configuration is K1 with all the services located on each of the application servers. The question to be answered is in what context (traffic deviations) and for which scenarios configuration K4 is optimal.

The above dilemmas will be dealt with in our future research supported by simulations and measurements made on a real test bed. Our work will involve all the analysed services and the various scenarios for the user behavior and services and for improvement of the cost functions.

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