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A Heuristic Approach for Service Interoperability in Web Service Oriented Smart City

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Abstract—*Service delivery and interoperability of services over network based protocol or web is an important concern in today's context of smart city service development. As such we propose to investigate some aspects of quality concern in multi nodal service interoperability against different load of consumers of such services. This paper will highlight the experimental bench mark that can be implemented along with the architecture and system testing results. The statistical analysis is being carried out to emphasize the feasibility of such service among the inhabitants of smart city.*

1. INTRODUCTION

Next generation of city, vision as smart city, will utilize the assets of city through Information and Communication Technology (ICT). As an inhabitant of smart city, people will acquire better service and efficient quality of life through flexible and secured ICT. The collaboration of different geographically separated nodal service in a smart city towards a specific goal or operational need of an inhabitant will enhance quality and productivity of operational output, will reduce cost, and will provide efficient resource consumption and contacts between citizen and nodal service providers. However, emphasize should also be given on massive consumers of smart city services and applications through ICT with the goal of improving the work flow of services along with real time collaborative execution [1]. The collaborative service oriented smart city system should be deployed by keeping in mind the effective responds of challenges against massive consumers of such service through ICT. Many studies had been carried out with different deployment model and test bed schemes which focus on deployment of smart cities as given in [2] [3] [4]. The state of art technique of deploying Web Services (WS) for collaborative nodal service execution in a smart city plays an important role. The WS can serve alone for a specific operation or can be executed in conjunction with other geographically separated WS to enhance Business to Business (B2B) collaboration [5].

2. RELATED WORK

The importance of platform independent service delivery over network and nodal service connectivity in smart city through ICT has increased considerably in world wide. Some studies have solely focused on service delivery through service oriented application and model along with the implementation methodology as in [6] [7] [8]. In the year 2009, P. Amirian et al. had discussed the ICT design consideration for interoperability of WS in smart city. They had highlighted some aspects of implementation issues of integrating WS considering the Tehran city of Iran and proposed approaches for effective solution to such issues [9]. In the year 2011, J. H. Munoz et al. had discussed about the platform for integration of huge component services through Internet of Thing (IoT), Internet of Services (IoS) considering real life applications in the context of smart city [10]. In the year 2015, A. Hussainet al. had demonstrated a methodology for health care system in smart city by considering the patient of disabled and elderly inhabitants. They highlighted some aspects of utilizing mobile devices for monitoring and generating emergency response in people centric environment. The experimental results had established the efficiency and cost effective applicability of such a system in smart city [11]. In the year 2016, F. Palmieri et al. had presented an architectural framework for handling emergency and crisis events occurred in large urban areas of smart city. The investigation was carried out by considering a real time monitoring system along with several localized services, so that the emergency situations can be handled smoothly in smart city [12]. In the year 2016, A. Comi et al. had developed a modeling framework to demonstrate the effective implementation of shopping application and flows of service among inhabitants of smart city. They had demonstrated an analysis carried out in Rome and established that the affectivity of service is applicable up to some extent of inhabitants [13].

3. THE ARCHITECTURE AND METHODOLOGY

The architecture of the system is given in **Fig.1** below. It highlights the experimental benchmark for interoperability of services and contains three independent services implemented through WS. The load over this architecture is generated through a load testing tool named as Mercury Loadrunner [14] [15]. The tool produces the system generated user as Virtual User (VU) that can be assumed as consumer of WS [16] [17]. The system is implemented in 64-bit Windows Server 2008

R2 Standard operating system (OS). The hardware specification includes Intel® Xeon® CPU E5620 processor @ 2.40 GHz speed along with 8GB RAM. The load is generated from a remote machine having Windows XP OS with hardware specification as Intel® Pentium® Dual CPUE2200 processor @ 2.20 GHz along with 1GB RAM. The WS have been developed by using Java and Spring framework. The tomcat web server and MySQL database is used for business logic (BL) implementation in the WS. A data size of 15000 clinical instructions is prepared for experiment.

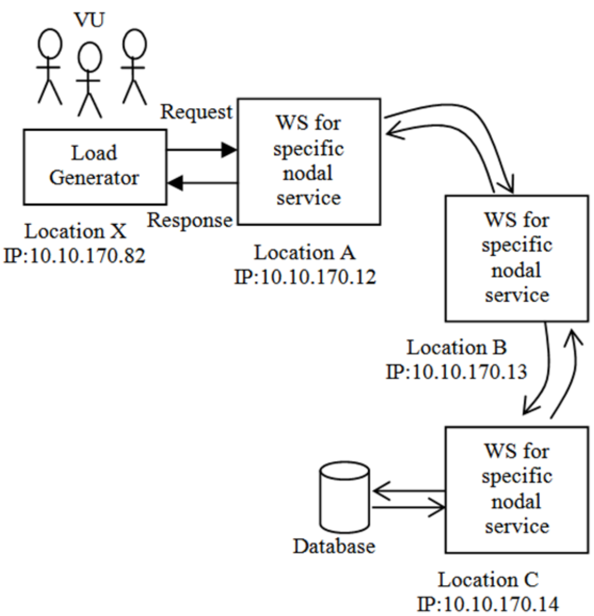

Fig. 1: The architecture and experimental arrangement for WS oriented smart city

4. TESTING

The testing is carried out by using Mercury Loadrunner against 100, 300, 500, 1000, 1600, 1800 VU to study some aspects of quality in this methodology. A test case is prepared that can pass parameter and read response from the system. The test case contains instruction to process SOAP request and response transactions among WS. A ramp up of 1 VU is set to enter the load every after 15 sec. After activation of all the VU, the group of VU will access the system for 5 minutes. The testing results against different VU are given in **Table 1**.

Table 1: Experimental results (Transaction: T_C, Response Time: R_T, Throughput: T_{PT}, Connection Fail: C_F)

Test case	VU	Avg. T_C	Avg. R_T	Avg. T_{PT}	Avg. C_F
SQL Select Query	100	892	1.4	10752.37	0
	300	3286	1.9	12203.21	0
	500	12829	2.1	22880.97	0
	1000	28489	2.2	26128.34	0
	1600	68228	3.44	47272.44	0
	1800	122622	25.85	102666.33	0.34

5. STATISTICAL ANALYSIS

A data sample of 30 repetitive testing is taken against 1800 VU to observe its normality. The normal distribution study through interpretation of histogram and normal probability plot predicts that the data sample follows normality in nature. The histogram and normal probability plot of response time and throughput are shown in **Fig. 2-3** and **Fig. 4-5** respectively.

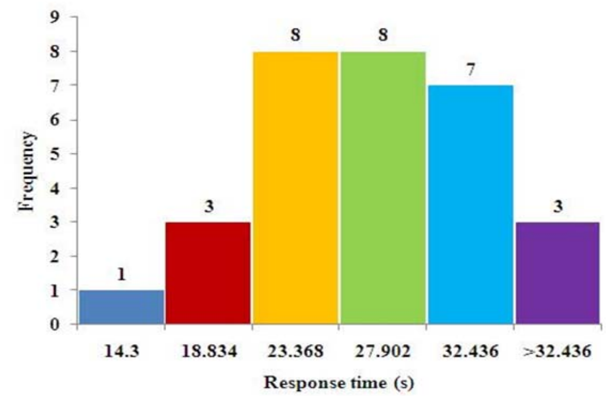

Fig. 2: Histogram of response time

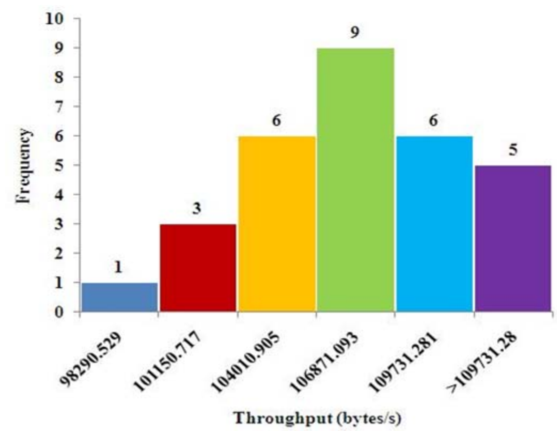

Fig. 3: Histogram of throughput

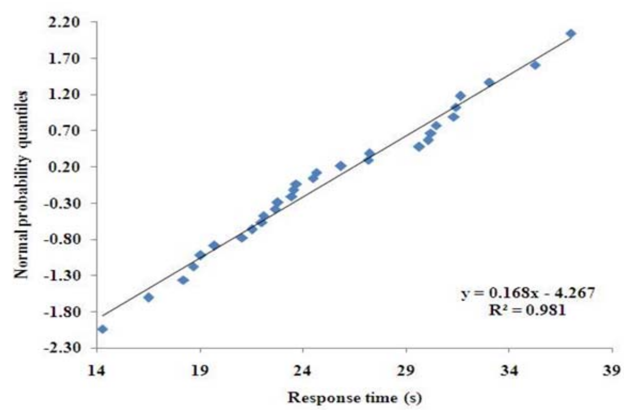

Fig. 4: Normal probability plot of response time

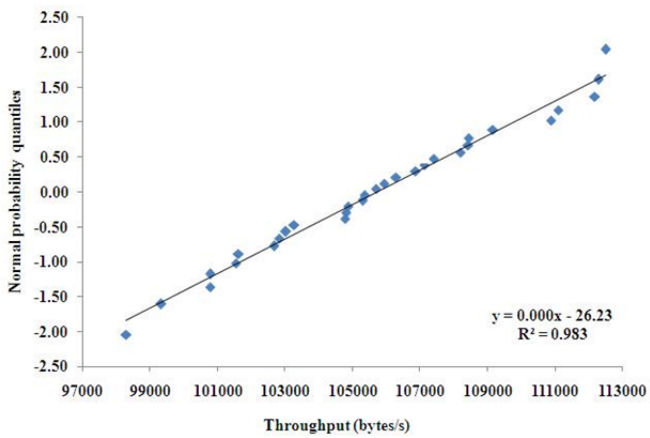

Fig. 5: Normal probability plot of throughput

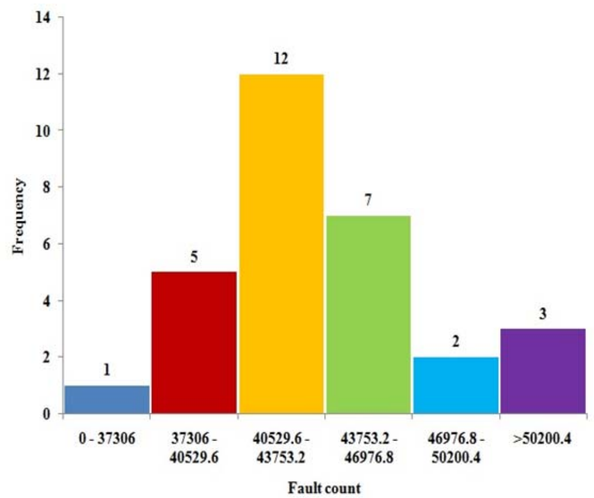

Fig. 6: Histogram of fault count

The fault count (FC) against 1800 VU is also recorded. The histogram for recorded FC is shown in **Fig.6.** The highest FC is observed in between 40529.6 to 43753.2. Each test case generates a HTTP request over the system. The request in turn generates SOAP instructions to other WS. In the data sample, an average of 126223.5 HTTP transactions had been occurred. Out of that, an average of 43836.1 transactions had failed during the overall execution of service interoperability.

6. OVERALL QUALITY ASSESSMENT AND DISCUSSION

The stability, scalability and interoperability of service for service delivery are observed up to 1600 VU. Beyond that the quality metrics degrades. As such connection refusal occurs. For which, the consumers may not get proper response during service time over web. The performance metrics increases gradually with increase in consumers. The reason is that with increase in consumers the overall server side resource utilization increases while processing bulks of request made through consumers. This hampers or conflicts the requests in processing. The plotting of data sample shows data are from normal distribution. The FC value is not observed up to 1600 VU. Beyond that a mean FC value of 43836.1 out of 126223.5 HTTP transactions is observed. The overall assessment for service interoperability through WS is given in **Table 2**.

Table 2: Overall assessment

Quality aspects	Results
Stability and scalability	Up to 1600 VU
Performance	Increases with increase in consumers
Histogram	Normal
Normal probability plot	Normal
Data sample normality	Observed
Connection failure %	Observed at 1800 VU
Mean FC up to 1600 VU	Not observed
Mean FC beyond 1600 VU	Observed. It is 43836.1

7. CONCLUSION

The interoperability of service in WS oriented smart city is feasible up to a specific load of users at a time. Beyond that some server side connection refusal may be observed. The stability and scalability for service delivery through service interoperability is observed up to 1600 VU level. As such the consumer will get proper response up to this level. This can be considered as good level for service delivery. Beyond 1600 VU some invalid response may be generated. From the overall assessment it can be concluded that service interoperability through WS oriented smart city is feasible, scalable and stable. The methodology can be implemented in smart city. As part of future work, we propose to study the service interoperability among different WS development techniques.

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