CHAPTER 8

CONCLUSION AND FUTURE WORK

8.1 CONCLUSION

Pervasive computing enables the user to connect to the network and receive any service anywhere any time. There is uncertainty in pervasive environment in terms of reliability, availability and trust. Pervasive environment consist of different service providers providing similar services with same functionality but possess different criteria. In this thesis, selecting a suitable service based on user’s preferences has been modeled as a multi-criteria decision making problem and an efficient, scalable service selection framework for pervasive environment has been proposed adopting PROMETHEE methodology (SSF_P) as well as ELECTRE methodology (SSF_E). Many user preferences and criteria such as service availability, service cost, reliability, trust, service provider capability, responsiveness, reliability, authorized/ unauthorized services, service provider mobility and locality of service provider that influence the selection of the service in pervasive environments were considered. Algorithms were designed for SSF_P and SSF_E and have been presented.

The computational analysis has been performed on the proposed framework for various service events. The initial registration overhead $O_{\text{preg}}$ for $n_p$ service providers offering $n_s$ services has been found to be $O_{\text{preg}} = 3\sum_{i=1}^{n_p} n_{si} + 2n_p$. The
The proposed Service Selection framework using PROMETHEE (SSF_P) and ELECTRE (SSF_E) has been simulated and the experimental results were obtained. Experiments were carried out to determine the service registration overhead, service provider withdraw overhead, service transfer overhead, service selection time and service selection delay. Experiments were also carried out to analyze the effect of the number of services on the service registration overhead and the effect of mobility on the service registration transfer overhead, service transfer overhead and Service Selection. The performance of the proposed SSF_P,
SSF_E framework has been also compared with the already existing framework SMARKS (Sheikh Iqbal Ahamed et al, 2009), TTMBP (Haibin Cai et al, 2009).

It has been found that the overhead increases linearly with the number of service providers. As the number of services for a particular service provider increases, the overhead also increases. It has been observed that the service registration overhead is lower for SSF_E, SSF_P. It has been also found that the proposed framework SSF_P, SSF_E shows 62% and 77% performance improvement in terms of service registration overhead over SMARKS and TTMBP respectively. It has been observed that the mobility of the service provider does not affect the service registration overhead and remains almost the same for different service providers.

It has been found that as the number of service provider withdrawals increases, it contributes to additional overhead which increases almost linearly to the increase in the number of service providers. It has been inferred that the service provider withdraw overhead is relatively high when the service providers’ mobility is high. It has been found that as the number of service provider transfer increases, the overhead also increases almost linearly. It has been observed that when the number of services is high, the service transfer overhead is relatively higher. It has been observed that the service selection time for SSF_P is less than SSF_E. It has been observed that the performance improvement in terms of Service Selection Time for SSF_P over SMARKS and TTMBP is 72.41% and 80.24% respectively. It has also been found that the performance improvement in terms of Service Selection Time for SSF_E over SMARKS and TTMBP is 37.08% and 54.47% respectively.
It has been observed that the number of criteria affects the service selection time. It has been found that the average performance improvement in terms of service selection time for different criteria for SSF_P over SMARKS and TTMBP is 84.56% and 87.33 % respectively. It has also been found that the average performance improvement in terms of service selection time for different criteria for SSF_E over SMARKS and TTMBP is 66.17% and 72.26% respectively. It has also been observed that the mobility affects the service selection time. It has also been observed that the performance of the proposed framework SSF_P, SSF_E is better in terms of service selection time for different mobility.

In this thesis, a novel Fault tolerant Service Selection Framework (FTSSF) has also been proposed. The proposed framework has been designed to have mechanisms to automatically complete the execution of the disrupted service during fault. Algorithms were designed for FTSSF_P and FTSSF_E and have been presented. Adequate theoretical analysis has been carried out and experimental results were obtained for the proposed framework and have been compared with the existing techniques. The results prove that the proposed framework is efficient and fault tolerant. An attempt has also been made to analyze the effect of mobility and load on the Fault Tolerant Service Selection Framework. The experimental results show that mobility and load affect the performance of the system.

If $n_p$ be the feasible set of service providers, $k$ be the number of criteria, $y$ be the number of faulty jobs and $n_f$ be the number of faulty service providers, then the Service recovery Overhead $O_{cr}$ for SSF-P has been found to be $O_{cr} = n_f y n_p \left( k (n_p - 1) + 5 \right)$ and the Service Recovery Overhead $O_{cr}$ for FTSSF has been found to be $O_{cr} = n_f y$. If $T$ is the total available time, $t$ is the execution time of each job and $N$ is the total number of jobs submitted for execution, then the
The number of completed jobs $N_c$ by $n_p$ service providers has been found to be

$$N_c = \sum_{j=1}^{n_p} \left( \frac{T_j}{t_j} \right).$$

The success rate (SR) of FTSSF for service providers has been found to be

$$SR = \sum_{j=1}^{n_p} \left( \frac{T_j}{N_j t_j} \right).$$

The number of completed jobs $N_c$ by $n_p$ service providers with $n_f$ faulty service providers has been found to be

$$N_c = \sum_{j=1}^{n_j} \left( \frac{T_j}{t_j + t_{rj}} \right) + \sum_{j=1}^{n_f} \left( \frac{T_j}{t_j} \right)$$

where $t_r$ is the recovery time of a faulty job. The success rate (SR) of FTSSF for $n_p$ service providers with $n_f$ faulty service providers has been found to be

$$SR = \sum_{j=1}^{n_j} \left( \frac{T_j}{N_j (t_j + t_{rj})} \right) + \sum_{j=1}^{n_f} \left( \frac{T_j}{N_j t_j} \right).$$

The proposed fault tolerant service selection framework has been implemented and the simulation results were obtained for the proposed framework FTSSF_P, FTSSF_E and compared with SSF-P, SSF_E and SHAPC. Experiments were carried out to find out the number of jobs completed, success rate, effect of load on the fault tolerant behavior, effect of mobility on the success rate, service recovery overhead and service delay during fault. It has been observed that the proposed framework improves the number of successful job completions. It has been found that the average number of jobs completed for FTSSF_P and FTSSF_E is higher than SSF_P, SSF_E and SHAPC. This is because the FTSSF_P, FTSSF_E restores the service execution quickly thereby enabling more number of jobs to be completed successfully. However, on ideal conditions, when there are no faults, the average number of jobs completed for FTSSF_P and FTSSF_E is lower than SSF_P and SSF_E. The results show that at a particular time $t$, the
success rate of FTSSF_P and FTSSF_E is higher than SHAPC, SSF_P and SSF_E. This is primarily because of the effective monitoring and fault handling of the proposed framework. It has been found that when the load on the service provider is higher, the performance of the system is relatively less and the success rate is higher for lighter load and lower for higher load. It has been found that the mobility of the service provider affects the success rate. It has been observed that for less mobility, the success rate follows the logarithmic function, \( y = a \ln(x) + c \). It is observed that for higher mobility, the success rate follows the polynomial function, \( y = ax^4 + bx^3 + cx^2 + dx + k \). It has also been observed that the service recovery overhead for the FTSSF_P/ FTSSF_E framework is very minimal and the average performance improvement in terms recovery overhead for FTSSF_P/ FTSSF_E over SSF_P/ SSF_E and SHAPC is 99 % and 80% respectively. This implies that the proposed FTSSF_P/ FTSSF_E are efficient. It has been observed that as the load on the service provider is increased, the service recovery overhead also increases. For higher load, the service recovery overhead is relatively higher and follows a linear function \( y = mx + k \). It has been observed that even when there are faults; the service delay is much lower for the proposed FTSSF_E, FTSSF_P framework. In addition, it is observed that the service delay increases exponentially for every increase in percentage of faulty service providers.

In this thesis, an efficient framework for selection of health care providers has also been proposed using ELECTRE methodology. The factors that influence the selection of the health care provider were identified as the specialist, medical experience, availability of the specialist, health care provider location, waiting time, capability, cost, success rate, clinical care, health care provider facilities, confidentiality and continuity of care. The health care provider selection has been modeled as a multi-criteria decision making problem. The proposed
framework has been implemented as an ASP.NET web service application using Microsoft Visual Studio 2008 C# in .NET Framework 3.5. The service selection time taken to detect the best health care provider as required by the patient has been determined for different number of health care providers for different preferences. It has been found that the time taken to identify the best health care provider varies between 5-30 msec. The results show that as the number of health care providers increases the health care selection time also increases. It has also been found that the number of preferences also influence the health care selection time i.e., higher the number of preferences, higher the health care selection time.

For the case study, six heterogenous Health Care providers were identified in a small town in India. The symptoms and preferences of two patients were obtained and the performance of our proposed framework has been analyzed. A study has been conducted to obtain the patient satisfaction among three geographical regions with 150 patients. The degree of patient satisfaction in the proposed framework is excellent as it is reliable, saves time in decision making and requires minimum effort on the patient.

In this thesis, an efficient, user driven service selection framework for social networking services has been proposed. The factors that influence the social network selection were identified. The Social network selection authority uses the PROMETHEE methodology to select the best social network organization based on user preferences. The algorithms for the proposed framework have been designed. The experimental results on overhead and social service selection time have been obtained. The service selection time for different number of criteria (factors) and different number of Social Network Organizations were obtained. Experimentation has been also carried out to determine the effect of the number of users (load) on the service selection time.
for different number of social network organizations. It has been found that the service selection time of the proposed framework is in a few milliseconds and when the number of Social Network Organizations are increased the service selection time also increases. It has been observed that the user load affects the service selection time i.e., greater the number of users (user load) greater the service selection time. The results show that the proposed framework is effective. Case studies were conducted in a closed group with 100 users to obtain the user satisfaction from the registered users. It has been found that 92% expressed that they are excellently satisfied.

In this thesis, a service selection middleware for cloud environments has been proposed using Promethee (SSM_PC) and ELECTRE methodology (SSM_EC). The algorithms have been designed for the proposed middleware. The factors that influence the selection of the cloud were identified. The cloud environment was simulated. The proposed middleware was also compared with SPSE and the performance was evaluated. It has been observed that the Cloud service selection time increases with increase in number of service providers in a cloud for different criteria k. It has been observed that the Cloud service selection time for the SSM_PC is lower than the SSM_EC. However, when compared to the already available algorithm SPSE, the performance of the proposed middleware is 57.81% and 32.51% better than SPSE in terms of cloud service selection time. It has been observed that the turnaround time for a particular job also increases with the increase in the number of service providers in the cloud. It has been found that the number of requirements affects the cloud service Selection time as well as the turn-around time. It has been found that the SSM_PC and SSM_EC provide 50.74% and 37.40% performance improvement in terms of turnaround time when compared with SPSE.
It has been observed that the average selection overhead increases with the number of service providers in the cloud. It has been found that SSM_PC and SSM_EC provide 51.74% and 35.79% improvement in performance in terms of selection overhead when compared with SPSE. It has been observed that as the number of users increases the service selection time increases. However, for a maximum of 1000 users, the service selection time does not exceed beyond 400 ms when the number of criteria is 10. It has also been observed that there is a performance improvement of 50.77% for SSM_PC and 40.18% for SSM_EC over SPSE in terms of Service Selection time. The experimental results prove that the proposed middleware is efficient.

8.2 FUTURE WORK

This section highlights the further directions in research on this domain.

a) The security features can be incorporated and investigated to propose a secure service selection framework in pervasive environments.

b) The fault tolerant behavior of the service selection middleware for cloud environments can be analyzed and suitable modifications can be made to the middleware.

c) The unique security requirements for cloud can be investigated and a secure service selection middleware for cloud environments can be proposed.

d) The service selection for intelligent transport systems and for other applications can be investigated.

e) The service composition for pervasive and cloud environments can be investigated and a new framework can be proposed.