

# Elastic Calculator : A Mobile Application for windows mobile using Mobile Cloud Services

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**Abstract** - Cloud computing is highly significant in this era as it always shows a way to increase the capacity or to add an additional features on the go and also it is worthy to extend these services to mobile devices. It is proposed to design and implement Elastic Calculator for mobile cloud services with virtual machines. The system comprises of a flexible application that was developed partly on own machine and partly on the cloud. Application is developed in two parts, with the front end and user interface at the mobile device and all the execution part is moved to the server running on the cloud. At runtime, the process execution is suspended at the mobile device and migrated from mobile device at a particular point to the cloud to perform all the computation and is later re-integrated back to the mobile device. This technique helps applications in achieving high processing efficiency with reduced energy on the mobile devices.

**Keywords:** Mobile,Elastic,VirtualMachine

## I. INTRODUCTION

Mobility and Cloud has become the buzz word and highly increasing in modern world of information technology area. An enormous growth in the design and development of mobile devices such as smart phones, tablets, laptops and GPS Navigation systems with a variety of mobility, processing ability, security and connectivity technologies[1,2].

As the smart phones and hand held devices pour into the market, there is also wide range of developers coming with a variety of applications that is capable of doing a lot more role in personal life more than just being a personal information management and a media player[2,3]. Nowadays, smart phones are used for playing games, capturing and editing of pictures and videos, managing finances, planning their schedules, hanging round in social media apps and browsing websites and portals. Lots of sophisticated applications have come that eases our life to a great extent like those of Pint rest, Heart Monitor, eBook Reader, Money Manager etc[3]. As the application capability, size and processing increases, there also occurs the need for faster and efficient execution platforms with enormous computing capability. It is now necessary to monitor the power consumptions, memory usage and efficient utilization of the mobile phones that runs these applications. It is also important to protect private data and manage applications containing malicious information.

The problem here is the limited resources available within the mobile phones which might not be sufficient as the more and more apps come up in the market with much more processing requirements. To overcome this problem, the power of mobile computing can be combined with cloud computing and that brings an incredible solution to the challenges that are faced in modern mobile devices.

To address this problem, we realize our Elastic Execution which provides an efficient architecture to make use of the available resources and save the process utilization and battery consumption of the smart phones[4,5,7].

In this method, the smart phone utilizes the bandwidth available and tries to reduce the computation and processing done in the mobile device[5,6]. Since, in recent years the network connectivity is made easily available to all smart phones and the bandwidth is also highly increased after the arrival of 3G services, the cost for the internet has come down remarkably. Thus, the phone makes use the bandwidth as much as possible and saves the internal processing very much. Thus, the necessity for high configuration is much reduced there by making the mobile phones cost economical.

## II. SYSTEM SETUP

### A. System Architecture

The architecture of the system follows the traditional client-server pattern and it proves worthy in this system. The concept of elastic cloud can be implemented with an application designed to use with the windows phone. As to meet the goals of the system, the application can be developed in two partitions. The user interface

is developed in the windows phone client which is executed locally. All the computational part is moved to the server that is running on the cloud, which has more processing capacity than that of the mobile phone.

To implement the above system, a Scientific Calculator is designed. The front end and interface parts such as the numbers, and others functional keys and spaces for the input, output, time taken can be developed in the Windows Phone emulator and the calculation part can made with the server program created with visual studio inside the cloud Virtual Machine.

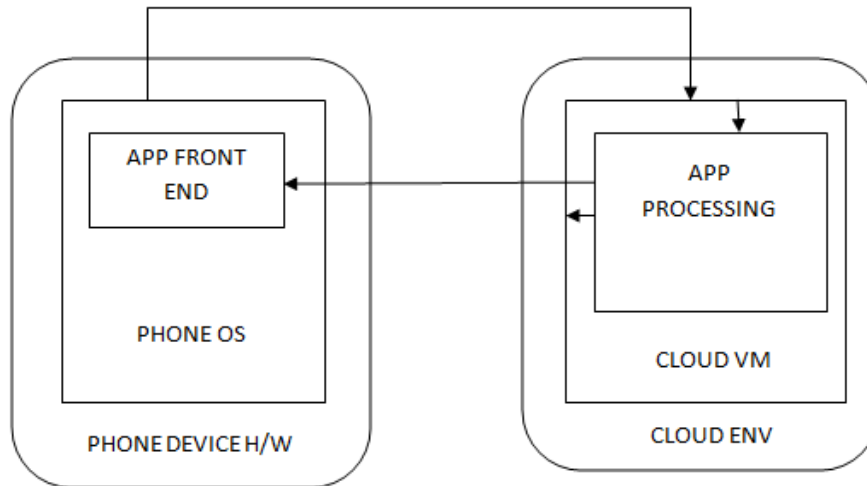


Figure 1: System Architecture

The execution process from the client side is kept in hold and the process thread is moved to the cloud server, once the execution gets over in the cloud and the corresponding result is brought back to the client phone. This is integrated back into the client machine and the process is continued.

### III. IMPLEMENTATION

#### B. Front End Design

The front end of the system must contain all the features of the calculator, such as the number keys, arithmetic operation keys and keys for some special functions. In addition to that, it also contain the special characters that are combined with these functions. The code for each and every key i.e buttons created must be written to activate the corresponding action on request. In addition to those math keys, a text box for displaying the input, output of the calculation, time taken for the calculation and one more to enter the IP address of the remote server is also developed .The front end design of the application on Windows Phone is made as follows,



Figure 2: Windows Phone front end design

### C. Cloud Virtual Machine Construction

Using the windows azure cloud account, the suitable virtual machine for the system is configured and created. The necessary software needed for the project, in this case visual studio is installed inside the virtual machine.

The allocation of the cloud VM is carried out in two steps, first the system has to be provisioned based on the attributes which is specified by the developer. The provisioning process takes some time and gets provisioned.

Now the virtual machine is ready and it has to be started. Click Start button at the bottom of the page. The VM will be started. The state of the machine is changed from "Stopped" to "Running". The status of the system along with the configurations mentioned as above are all can be viewed by clicking on the VM name and selecting the Dash option from the top menu ribbon of the screen. When system comes to running state, click on the "Connect" button at the bottom. A .rdp file will be downloaded. Save this file anywhere in the system.

The .rdp file contains the parameters that are required to connect the local machine to the Cloud server. It includes the DNS Name, port number and the protocol used for connecting them. The rdp file is the only way through which we will be able to enter into the the cloud VM and it has to be saved carefully.

### D. The Expression Evaluator

The expression evaluator program is written inside the server. The function of evaluator is to read the mathematical expression that was received, evaluate it and give back the result. The expression evaluator was written in C# with Visual Studio 2010.

The expression evaluator parses the expression read into characters and forms a parse tree structure with match from the set of predefined keywords. It takes into account the order of precedence of each and every operator and computes it accordingly. The mathematical functions like Log, Sin, Cos, Tan are treated separately as functions with the parameters passed to it. These mathematical functions are tested individually for the correctness of the answers and are inherited in the main expression evaluator in addition to the arithmetic operation evaluation.

### E. Establishing the client and cloud server connection

The Virtual Machine that is created inside the windows azure cloud has its own properties. The VM has two IP addresses one is Internal IP address that is used for the connections that run inside the local machine. The second one is the Public IP address called as Virtual IP(VIP), that is defined for every virtual machine by default. This public VIP remains constant anytime for that particular virtual machine and can be used to access the virtual machine from anywhere at any time.

We also need to define the end points inside the virtual machine. The end points are the ports through which the cloud server listens and establishes connection. The end points are defined as follows. Login to the Windows azure development portal, select the "Virtual Machine" option from the sidebar and click on the virtual machine name. Click "Add End Point" option at the bottom ribbon. The add end point window appears as follows. Select "add end point" radio button from the next window and click "Next". Specify the details for the end point in next window which appears. From the client machine, the connection to the cloud is established with the public Virtual IP address (VIP) through the port that was defined in the Windows Azure Portal.

To execute the application make the server inside the cloud listens to one of the end public points created and run it. Also run the mobile application from local machine connecting through the same end point port that server listens. Enter the expression from the client and on clicking "Calc" the expression is passed on to the server and response received is displayed on mobile device along with the round trip time taken by the system. It is given on the figure below.



Figure 3: Execution and received result

#### IV. RESULT & DISCUSSION

The application mainly concerns about saving the processing power of the system and thereby saving the battery consumption with minimizing the executions and processing that is occurring otherwise in the phone local machine. Since every execution is taken to the cloud server and the results are brought back, there is also some time lag in the process comparatively when executed at a remote place. The time taken for the transfer of data depends on the speed and bandwidth of the network connection used.

Here we study this time factor for some mathematical calculations that was executed both at the client and the server side. To come up with an average time taken, we execute every input for some five times and arrive at the execution time.

We tested here with 3 inputs of data first with just an addition of integers then with multiplication of decimal fractions of five digits then last with a trigonometric function.

The input and the corresponding time taken are given as follows,

A. Input 1: 27+38 (Time in milliseconds)

TABLE 1  
Response Time for Input 1

Trials	1	2	3	4	5
Local Machine	27	7	7	8	9
Cloud	142	159	162	114	210

The Average execution time at local machine is: 11.6 ms

The Average execution time at cloud is: 157.4 ms

Total data transfer: 9 Bytes.

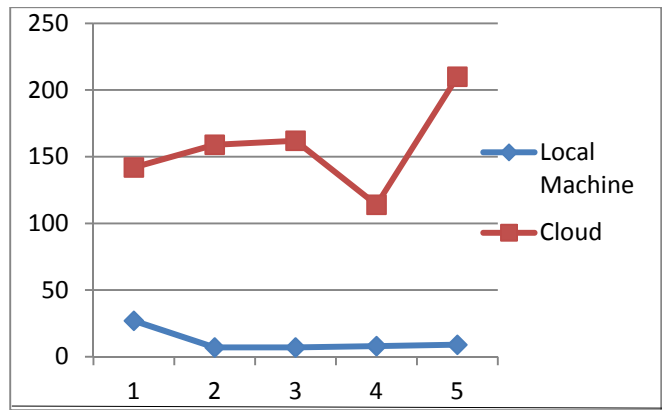


Figure 4: Response Graph for Input 1 (X-Trials, Y-Time in milliseconds)

B. Input 2 :  $278.94 * 834.98$  ( Time in milliseconds)

TABLE 2  
Response Time for Input 2

Trials	1	2	3	4	5
Local Machine	19	7	8	7	18
Cloud	240	143	181	114	170

The Average execution time at local machine is: 11.8 ms  
 The Average execution time at cloud is: 135.4 ms  
 Total data transfer: 21 Bytes.

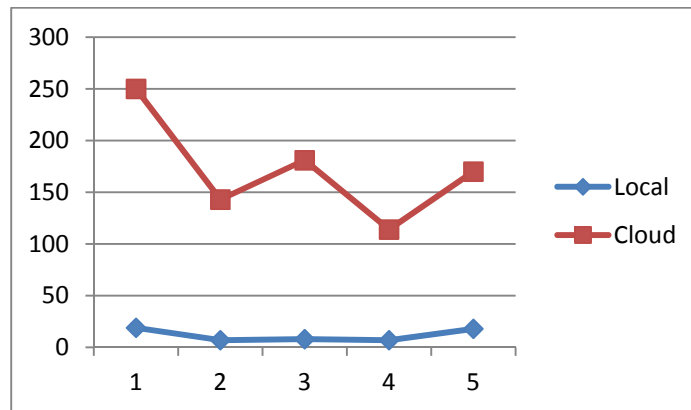


Figure 5: Response Graph for Input 2 (X-Trials, Y-Time in millisecond)

C. Input 3:  $\text{Log}(72,3) + \text{Sin}(1) - \text{Cos}(0) + \text{Exp}(3)$  ( Time in milliseconds)

TABLE 3  
Response Time for Input 3

Trials	1	2	3	4	5
Local Machine	7	9	8	12	10
Cloud	109	153	226	216	120

The Average execution time at local machine is: 9.2 ms  
 The Average execution time at cloud is: 164.8 ms  
 Total data transfer: 53 Bytes

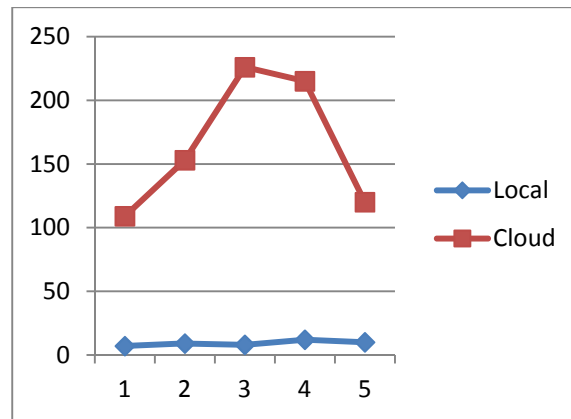


Figure 6: Response Graph for Input 3  
(X- Trials, Y-Time in milliseconds)

The above calculations and graphs are drawn only taking into account with respect to the time constraint. Even though when time is considered, there is some delay in cloud, it is tolerable as the total time taken for the transfer is averaging around 150 ms.

When large calculations are made, the cloud resources proven to be more efficient than the phone. In such cases, the time delay is easily neglected as the processing efficiency is highly increased and the phone resources are saved.

#### V. CONCLUSION & FUTURE WORK

We succeeded in developing an application that runs at the smart phone and partly in cloud so as to increase the efficiency of the smart phones to a great extend and thereby saving resources too. We would like to mention the scope for improvements in this work.

The critical factors taken into account here are processing efficiency, battery consumption and time for execution in the smart phones. We have very well analyzed the time factor in both the local and the cloud machine, however as we are working on the emulator and not the actual phone, we are not able to assess the exact CPU utilization happened in the smart phone. Even though it is obvious that some significant processing would be saved in the phone, we were not able to arrive at the exact metric of the processing. Similar is in the case with battery consumption. We were not able to assess exactly how much battery would have been consumed and saved when the same process is run on local machine and remote cloud. These criteria's can be studied further in detail to make a profitable outcome of this idea.

We also feel that the cloud server part could have been more efficient if it was constructed on a private cloud rather than on a public cloud as we have certain limitations to use the public cloud.

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