Practical Use of Windows Data Collector: Development Process and Testing Analysis

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Abstract—The paper demonstrates the Windows data collector development process with the built back-end from the requirements gathering stage till the implementation and testing phase. Each phase throughout the development lifecycle of the system is defined in details. The whole system idea and the objectives behind developing this kind of framework is described in earlier papers that creates the importance of introducing the background before reading this paper. The detailed information about the data collector features that are provided and their appropriate testing types, documentation are demonstrated thoroughly. Be sides, the process of development includes both design and overall system architecture description.

Index Terms—Windows data collector, Software development process, process metrics, data collector implementation, data analysis

I. INTRODUCTION

During the research survey in the field of embedded systems referring the energy related metrics collection it has been an evidence that the battery draining applications result in overall bad user experience and dissatisfied users [1]. The optimal battery usage (energy usage) is an important aspect that every client must consider nowadays [2]–[5]. Application energy consumption is dependent on a wide variety of system resources and conditions. Energy consumption depends on, but is not limited to, the processor device uses, memory architecture, the storage technologies used, the display technology used, the size of the display, the network interface that you are connected to, active sensors, and various conditions like the signal strength used for data transfer, user settings like screen brightness levels, and many more user and system settings [6]. The windows data collector is a tool for estimating the software development process efficiency by collecting process metrics non-invasively [7]–[11]. In addition, while estimating the overall process efficiency, the energy consumption metrics are the main novelty of our system.

Modeling the energy consumption of applications, gathering valid data from active and passive application processes (i.e., applications in focus and those out of focus) is a crucial activity which can be used to find correlations and trends in various areas of research such as developer’s productivity [1], applications with the highest energy consumption profiles and more. To this aim, there have been proposed hardware based tools [12] as well as model based and software based techniques to approximate the actual energy profile of applications [13]–[15]. However, all these solutions present their own advantages and disadvantages. Hardware based tools are highly precise, but at the same time, their use is bound to the acquisition of costly hardware components. Model based tools require the calibration of parameters needed to correctly create a model on a specific hardware device [6]. Software based approaches are cheaper and easier to use than hardware based tools, but they are believed to be less precise [12], [16]. Moreover, the collected metrics can serve a variety of other purposes, from planning, to monitoring, and then to revising post-mortem software projects [17]–[33]. To this end, techniques from machine learning and computational intelligence are particularly useful [25], [34].

II. REQUIREMENTS ENGINEERING

Before the analysis of the data collector and designing its overall architecture, we had a series of requirements both functional and nonfunctional that were set so as to govern the design and implementation of the application. These requirements established the features and functionalities that the client requires from the application. These requirements also specify the constraints under which our system should operate and will be developed. The functional requirements are the following:

• The list of collected metrics should be easily modifiable;
• The metrics should be collected and sent to the back-end database automatically after authorization;
• The time interval to send the data to server should be
specifiable;
- The collector should support automatic updates;
- Clients should be able to send error reports;
- Energy-related metrics should be collected;
- Product metrics should be collected;
- Collectors should implement search functionality. We aim at gathering valuable data related to each running application process. We choose the following quantities to monitor; process name, process id, status (app focus or idle), start time of the process, end time of the process, IP address, mac address, process description, processor, hard disk, memory, network and input/output usage.
- Data being collected can be subdivided into 2 parts:
  - Process metrics which include: process name, process id, status (app focus or idle), start time, end time, IP address, mac address, process description, and
  - Energy-related metrics which include: CPU, memory and ram usage.

Similarly, the nonfunctional requirements of the collector are modifiability, maintainability, adaptability, security, reusability, and reliability of the system. With these requirements in place, analysis of the developed application and documentation of the design decisions were made.

After the requirements are collected, the analysis phase was took a head on the development life cycle of the system. The iterative analysis process which continues until a preferred and acceptable solution or product emerges was used. During the analysis of our system, factual data was collected (i.e., what is lacking, what was done, what is needed, etc.). Understanding the processes involved, identifying problems and recommending feasible suggestions for improving the systems’ functioning was done. This involved studying logical processes, gathering operational data, understanding the information flow, finding out bottlenecks and evolving solutions for overcoming the weaknesses of the system so as to achieve the overall goal for the collector. Furthermore, the subdividing of complex processes involving the entire system and the identification of data store and manual processes were made [35].

III. DESIGN

Understanding that our application will mostly run in the background as a daemon, we needed simple, scalable, and native approaches to display and collect data.

A. Use case diagram

During the early stages of the development phase, there was a need for a simple but purposeful representation of the entire system. By means of this representation the followings were specified:
- Specify the context of the system;
- Capture the system requirements;
- Validate the system architecture;
- Drive implementation and generate test cases based on it. This use case diagram (See Figure 1) describes the best of thinking process where was involved creative skills. The attempt of to give ideas to an efficient system that satisfies the current needs of the clients and the ability to grow in the organizational constraints.

B. System architecture

The system architecture describes best all the quality attributes like scalability, fault tolerance and adaptability derived from the requirements. In order to assure that kinds of quality attributes, the system was developed using micro services architecture such as Analytical Service, Administration service, Authorization service and etc.

The data collected is stored in a lightweight database locally on the user’s machine for particular period of time and then automatically translated to the server side. This is an efficient way to ensure persistence and integrity in case of unexpected run time error or system shutdown. The local database maintains collected data and checks sent data on each successful transfer to the back-end to avoid data duplication and inconsistencies.

For an initial deployment of the solution, there is a server that will host all the services shown in the Figure 2.
IV. IMPLEMENTATION

To provide the system help the developers and to start the data collection process and validate the data model, the system with a monolithic API was developed. Besides, in order to provide the system with the required nonfunctional requirements, the second version of the system with different components, where each service has a particular purpose. The system was created based on microservices with two main access points and a series of specialized services such as:

- Analytic Service - to be able to extract information from data collected and to carry out the data transformation referring the model that is suitable for end user.
- Administration services - to provide functionalities that allow to make configurations in the system as a user and administration.
- Authorization service - to authenticate and authorize the users, to generate and validate tokens to process requests from various services.

The architecture of the system included decision making process, to achieve the stated requirements. The program, including submodules and services, were written as to coordinate data collection, data storage, data transfer and control the entire processes built into our system. The code was well written to reduce the testing and maintenance effort [35]. This helps in fast development, maintenance, and future changes if required. Visual Studio Community 2019 version and the C# programming language was used [36], [37].

V. TESTING

After developing the various features of the windows collector and sticking to the constraints specified in the requirements document. From the windows data collector perspective, the back-end has to carry out several tasks including but not limited to the following:

- Account verification (at login and registration)
- Receive data sent by a user

Before deciding to install our system and put it into operation, a test run of the system was done removing all the bugs as necessary. The output of all our tests matched the expected results. We ran the two categories of test:

- Program test. Referring to our requirements for the expected results of our system, coding, compiling and running our executable was the routine. After our locally based collector application was up and running, each use case of our system was tested to match the expected outcome. We carried out various verification and noted unforeseen happenings which were eventually corrected.
- System test, which implies running of the overall system with the back-end and making sure it meets the specified requirements were done. Our system was fully developed and ready for usage by clients.

After testing our data collector for a long period of time, and running queries in the back-end to export collected data into CSV format, we obtain the following result (Figure 3). Added to the previous system test, this validates that our developed collector successfully communicates with the back end without loss of data.

VI. CONCLUSION

Battery draining applications result in bad user experience and dissatisfied users [1]. Optimal battery usage (energy usage) is an important aspect that every client must consider nowadays [38]. Application energy consumption is dependent on a wide variety of system resources and conditions. Energy consumption depends on, but is not limited to, the processor the device uses, memory architecture, the storage technologies used, the display technology used, the size of the display, the network interface that you are connected to, active sensors, and various conditions like the signal strength used for data transfer, user settings like screen brightness levels, and many more user and system settings [6].
For precise energy consumption measurements, one needs specialized hardware. While they provide the best method to accurately measure energy consumption on a particular device, such a methodology is not scalable in practice, especially if such measurements have to be made on multiple devices. Even then, the measurements by themselves will not provide much insight into how your application contributed to the battery drain, making it hard to focus on any application optimization efforts.

The collector aims at enabling users to estimate their application’s energy consumption without the need for specialized hardware. Such estimation is made possible using a software power model that has been trained on a reference device representative of the low powered devices.

Using the PerformanceCounter, PerformanceCounterCategory and many more related classes (made available by the .NET Framework) [36], [37], the energy usage can be computed. Performance counter(s) provided information such as CPU time, Total Processor Time per process, CPU usage, Memory usage, network usage and more. The MSDN documentation was used to better understand how we could utilize the available components in attaining our goal (collecting energy consumption metrics).

Need to mention that it is difficult to match up constantly changing application process IDs and names. Also, imperfectations in the designed power model as energy consumption depends on a variety of factors not limited to those we can collect using these available performance classes.

In this report, we have presented the requirements that play the crucial role in the system development, the design and the overall system architecture details, a deeper view of how the data collector operates with the back-end, analyzed the use cases, the testing phase with some results displayed of testing, and stated the drawback experienced during this process.

The plan is to release the collector with some open source license to ensure its maximal distribution [39]–[43].

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