Reliability Assessment Model for Big Data Structure of Internet of Things

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Abstract
To improve Big Data reliability, the Big Data Structure of Internet of Things should consider different reliability rules while building the Big Data Structure of Internet of Things. In this paper, an assessment model to assess Big Data Structure of Internet of Things is presented. This assessment model is based on two different reliability rules: connection degree and relevance. The main goal of this research is to implement an early assessment of the Big Data Structure of Internet of Things for the purpose of its improvement in order to make the assessing process more productive. Structure Design is an important problem in Big Data engineering. It makes assessing more productive as it executes the assessing in an initial stage of the Big Data development. This assessment model consists of two phases: Big Data Structure of Internet of Things assessment phase, and module assessment phase. The model is confirmed by using a case study: Environmental video System. In each phase, a logical reasoning system is used to perform the assessment process based on connection degree and relevance assessing rules. The experimental results show that assessment model is efficient and gave a certain improvement to the Big Data reliability process.

Keywords: Big Data, Reliability Rules, Structure Design, Logical Reasoning

1. Introduction
Many studies have been implemented to address big data assessing to reduce big data assessing efforts by handling big data reliability at initial stages in the big data development life cycle (BDDLC) [1-7]. Big data reliability (BDR) is the reliability attribute about the easiness degree to which system’s defects can be detected at assessing phase [4]. Researches show that more than forty percent of Big Data development efforts are spent on assessing, with the percentage for assessing critical systems being even higher [2, 3]. The better the reliability of particular Big Data, the lower the assessing effort required in assessing phase. Moreover, the earlier the reliability is considered, the lower the cost of assessing phase. Big Data Structure of Internet of Things (BDSIT) provides a high level of abstraction of Big Data represented by Big Data modules and the connections between them. Thus, BDR should be considered at the early phases of Big Data Development Life Cycle (BDDLC), specifically in the Big Data Structure of Internet of Things (BDSIT) [3, 4]. Big Data Structure of Internet of Things should consider the reliability rules while building the BDSIT in order to improve Big Data reliability.

A model (Structure Design Assessment Model (SDAM)) is presented in this paper to implement an early assessment of the Big Data Structure of Internet of Things in order to make the assessing process more productive. SDAM assesses the BDSIT based on connection degree and relevance reliability rules. Logical reasoning system is used in the assessment process to assess the reliability of BDSIT according to a proposed set of reasoning rules. The model is implemented and applied on a case study (Environmental video System) to ensure its applicability and productiveness. The main activities of this model are:
1. Highlight the set of modules in BDSIT that should be improved to increase BDR.
2. Classify Big Data modules based on their level of assessing effort.
3. Assess Big Data modules reliability based on connection degree and relevance reliability rules.
4. Assess Big Data reliability based on connection degree and relevance reliability rules.

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2. Related Work

The relationships between these rules and the assessing process are evaluated. These rules are: depth of inheritance tree, fan out, number of children, number of fields, number of methods, response for class, and weighted methods per class. In [7], statistical analysis techniques, mainly correlation and logistic regression, are used in order to evaluate the capability of lack of connection degree rule to predict reliability of object oriented classes collected from two java Big Data systems. Another class based reliability rules is proposed in [6]; which detects potential reliability weaknesses of a UML class diagram and points out parts of the design that need to be improved to reduce the assessing effort. In addition, it proposes a methodology for improving design reliability. Some studies focus on assessing system reliability based on object-oriented rules derived from system design [7-9]. In [5] a set of object-oriented rules are defined to assess the reliability of classes in a Java system.

The main focus of this work is to select near-optimum clustering of methods and attributes into objects with moderate connection degree and relevance. However, this approach applied to Data Flow Diagrams (DFD) that does not express information about process hierarchy. In this paper, the assessment is based on relevance and connection degree reliability rules that are derived from the Big Data Structure of Internet of Things. Both Big Data and Big Data modules are considered in the assessment process. Here proposed a set of object oriented reliability rules [9]. The JS rules were evaluated in [8, 10, 11], to investigate the relationship between these rules and unit assessing. A JS rules are also used as a base for a logical reasoning system to assess the reliability efforts [2]. It uses object and system reliability rules. In [11], object-oriented modeling techniques are used to help the product development team on the generation of the best fitted hardware/Big Data Structure of Internet of Things for a given problem under given constraints.

3. Proposed Model

The proposed approach consists of two phases (as shown in Figure 1).

In the first phase, Big Data Structure of Internet of Things is assessed according to the studied reliability rules. In this paper, BDSIT assessment model is proposed. The assessment is based on connection degree and relevance reliability rules. This assessment gives an indication on the required assessing efforts for the entire Big Data. The logical reasoning system is used to perform the assessment process based on these rules. If Big Data required significant assessing efforts, the second phase is performed to help in improving Big Data reliability and reducing assessing efforts. Modules’ assessment specifies the assessing efforts required for each module. After assessing all modules, the structure can tell which module(s) required more effort for assessing. Moreover, in this phase, each module in the BDSIT is assessed using the logical reasoning system. This process can be iterated as long as the system and modules functionalities are maintained. In the following sections, the proposed model is discussed in details. Then, this module is modified to increase its reliability; consequently, the whole Big Data reliability [12].
4. Big Data Structure of Internet of Things Reliability Rules

4.1. Relevance Degree
Relevance degree describes the interconnection between system modules. Both module relevance (CCop) and system relevance (SCop) are considered. Module relevance can be described as the relation between module \( i \) and other modules in the system as the number of fan-in and fan-out. It is calculated by Equation (1); as the ratio between the number of edges interconnecting module \( i \) and the total number of edges within system Structure.

\[
CCop = \frac{\sum_{i=1}^{n-1} e(i)}{E}
\]  

where \( n \) is the number of modules, \( e(i) \) is the number of edges of module \( i \), and \( E \) is the total number of edges in the system Structure. In addition, module relevance describes the module dependence (CDep), which is the number of modules that depend on module \( i \). CDep is calculated using Equation (2).

\[
CDep = \frac{\text{the } i\text{th component dependency tree}}{n}
\]  

Where the \( i \)th module of dependency tree is the tree rooted at module \( i \). All other modules that depend on module \( i \) are its children and its descendants. Figure 2 shows the attachment relationship in which Figure 2 (a) presents the beginning Structure and Figure 2 (b) presents the relevant attachment relationship for module A. System relevance can be described as the Cumulative Module Dependency (CMD) which calculates the dependences for all modules in the system using Equation (3).

\[
CMD = \frac{\sum_{i=1}^{n} \text{The } i\text{th Cumulative Module Dependency}}{n^2}
\]  

The interconnection between system modules (SCop) is calculated by Equation (4).

\[
SCop = \frac{\sum_{i=1}^{n} CCop}{n}
\]  

Where \( n \) is the number of modules in the system.

\[
CCoh = \left( \frac{E}{MC} \right)
\]  

4.2. Compact Degree
The module connection degree (CCoh) is calculated for the system Structure to compute assessing efforts. CCoh is the connectivity between system module, and it represents the module connectivity [3]. It is calculated by Equation (1); where the ratio between the numbers of module edges (\( E \)) and the maximum connectivity of the system (MC) is calculated [9]. The maximum connectivity corresponds to a complete graph which the total number of module is calculated by Equation (6).

\[
MC = \frac{1}{2} \times n(n - 1)
\]  

Where, \( n \) is the number of module. If \( n = 1 \), then CCoh = 1. System connection degree (SCoh) is the average of the summation of modules’ connection degree, and it is calculated using Equation (7).
Where, \( \text{CCoh}(i) \) is the connection degree of the \( i^{th} \) module.

\[
S\text{Coh} = \left( \frac{\sum_{i=1}^{n-1} \text{CCoh}(i)}{n} \right)
\]

Figure 2. (a) The beginning structure, (b) The relevant attachment relationship

5. Logical Reasoning System

The higher the value of this variable, the worse the assessing effort required to test the system/module. As for input variables, the membership functions are uniformly distributed over the range 0 to 1. The membership functions are uniformly distributed over the range. The output from the logical reasoning is the assessing effort. This variable has five values; very low, low, medium, high, and very high.

John reasoning system consists of three steps. The John logical reasoning system is used to control the model and combine it with a set of linguistic control rules. The John uses three inputs and one output reasoning system. The first input variable is the connection degree (Coh). It could be CCoh or SCoh. It has three values; low, medium, and high, each has a membership function. The second input variable is the relevance (Cop), which could be CCop or SCop. Cop has three values; low, medium, and high. Finally, the third input variable is the dependency (Dep), which could be CDep or SDep. Dep is also has low, medium, and high values. The range of membership functions for all input variables is between 0 and 1.

In input logical step, the value of each input variable is mapped to a logical value according to the corresponding membership function. The second step is rules assessment and aggregation. In this step, input logical values are evaluated according to the reasoning rules, where values: L is Low; M is Moderate; H is High; VL is Very Low; and VH is Very High. Then, all matched rules are aggregated to generate the logical output value. The third step is the non-logical step where the output is mapped from logical domain to an output value.

Proposed Model Phases:

In this phase, the system Structure is assessed based on SCoh, SCop, and CMD. These rules are calculated using equations 2, 6, and 5 respectively. The calculated values are entered to the logical reasoning as Coh, Cop, and Dep respectively. The proposed model consists of two phases; system assessment and modules assessment. In this section these phases are discussed in details. The output from the logical reasoning is the effort required for system assessing. If this value is significant, phase two can be performed to reduce this value as much as possible.

These values are evaluated using the logical reasoning to know the assessing efforts for that module. This process is repeated for each module. At the end of this phase, modules are classified according to their assessing efforts. This will direct the structure to the group of modules that require a high assessing effort. The purpose of this phase is to classify system modules into different classes according to its assessing efforts. To assess modules reliability, module CCoh, CCop, and CDep are calculated according to Equations (1), (3), and (4) respectively. Then, he/she can modify them to decrease their required assessing effort which means increasing the system reliability.
6. Results and Analysis

For sending out an alert, the value of network status is checked. If cell network is available, then a call is dialed. In case there is no cell network but Wi-Fi network is available, then a message is sent out with the user location. For the worst case scenario of no networks being available, the alarm signals for help nearby.

The subsystem works as follows: Once a fall is detected, the network availability (cellular or Wi-Fi) is checked. For displaying user location in map view, the location co-ordinates are scanned and sent to one of map services using a Java Script Object Notation (JSON) query to retrieve and detect the location. If there is no network available, then a recently cached location is used and GPS-based positioning scanning is stopped to prevent battery drainage. The model has been tested using fall detection-response subsystem from Helping Our People Easily (HOPE).

The Structure consists of seven modules; four of them have several modules. When applying the proposed model, firstly, phase one will evaluate the reliability of the entire system. Since system assessing effort that results from phase one is moderate, phase two will evaluate the reliability of each module. The model was implemented using Matlab Big Data and applied on the Environmental video system Structure.

As a result, the connection degree of alert transmitter module is increased by connecting call dialer and message transmitter modules to alert raiser module. As a result, the structure can modify these modules in order to reduce entire system assessing efforts. This is can be done by increasing the connection degree and decreasing the relevance of the modules that required high assessing efforts. In addition, it shows the assessing effort (TE) for each module that result from the logical reasoning system. Notice that, three modules out of seven have high assessing effort (the highlighted modules: network scanner, power source and alert transmitter module). The assessment results for Environmental video system Structure list the connection degree and the relevance values for each phase.

The Structure is assessed again to evaluate the modification results. Another modification, to increase the connection degree of power resource module is to separate the charger module into different module since it does not have any connection with battery module or any other external modules. By this modification, the relevance between call dialer and alert switcher, and message transmitter and alert switcher are eliminated. Thus, need to reduce the total relevance of alert transmitter module. The comparison between system connection degree, relevance, dependency, and assessing efforts before (called system_B) and after (called system_A) the structure modifications. SCoh increases after Structure modifications. In addition, SCop and CDD is reduced by 14% and 21% respectively. These enhancements results in reducing system assessing effort by 42%. The results are expressed the percentage values of the assessing efforts improvement, where “-” means the decreasing of assessing efforts. The system assessing effort is reduced by 42% since the assessing effort for power source and alert transmitter is reduced by 67% and 35% respectively.

7. Conclusion and Future Work

A logical reasoning system was built to assess both Big Data and module reliability according to reasoning rules. The model was implemented and applied on a case study. In this paper, we proposed an assessment model to assess Big Data Structure of Internet of Things (Structure Design Assessment Model (SDAM)) based on reliability rules. The results showed that the model is applicable and efficient and it can improve the reliability efforts. The model directs Big Data Structure of Internet of Things on how to improve Big Data Structure of Internet of Things reliability. As future works, we propose an adjustment logical rules and membership functions based on testable Structures.

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