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# SEMANTIC QUERY BASED INDUSTRIAL AUTOMATION AND ENERGY CONSUMPTION

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## ABSTRACT

The rapid evolution of technology in industrial automation systems requires tighter integration between devices on the plant floor and the rest of the enterprise. This integration requires a secure network infrastructure, smart devices for efficient data collection, and the ability to turn data into actionable information. The smart deliver of industrial automation and control through our control systems and smart devices portfolios. The combination of these platforms are architected and designed to helps for build the most efficient industrial automation system to meet our needs. A semantic query feature is added to the system such than an android application is held at the user end with capability of working with predefined commands that are meaningful to common people and this helps to obtain the sensor data at any instant as well as control the devices using these predefined commands that could be given as text input to the application. Also threshold of sensors used in automation could be set via android application and thus provides changes in the working condition of the system. This automation brings out optimized energy consumption and continuous monitoring of the system. This is possible by continuous evaluation of the energy consumed by the whole industry. Here a possible method is implemented and can effectively monitor the current consumption of the industry, the android application is modified such that the energy consumption details could be displayed on the application based on the queries assigned for the industrial needs and graphs can be plotted for easy and better analysis of the industry energy consumption. Also it can monitor the energy details of the different work units of the industry using this application as the system is integrated through internet, this possibility widens the use and application of this project.

**Index Terms:** Internet of Things, Industrial IoT, Gateway, Semantic Rule Engine, Energy Consumption.

## 1. INTRODUCTION

The Internet-of-Things (IoT) prospects to interconnect sensors, devices, gateways, and objects of an industry which solves many challenges. The Internet of Things is simply "A network of Internet connected objects able to collect and exchange data." It is commonly abbreviated as IoT. In a simple way to put it, have "things" that sense and collect data and send it to the internet. The successive interconnectivity through this devices plays an important role in the construction of a powerful industry. The analysis of energy consumption makes the industrial production with low costs while contributing to a better environment. This requires the whole industry automated with the help of IIoT. The IoT device will typically be connected to an IP network to the global Internet. Commercial IoT, where local communication is typically either Bluetooth or Ethernet (wired or wireless). The IoT device will typically communicate only with local devices.

### 1.1 GENERAL CONTEXTS

The Industrial Internet of Things originally described the IoT (Internet of Things) [23] as it is used across several industries such as manufacturing, logistics, oil and gas, transportation, energy/utilities, mining and metals, aviation and other industrial sectors and in use cases which are typical to these industries. The power of the internet of things comes from the ability to collect a lot of data and convert that into useful information.

The Industrial Internet of Things can be defined as ‘machines, computers and people enabling intelligent industrial operations using advanced data analytics for transformational business outcomes. Many advanced technologies [22] are implemented in industries with the support of IoT. The most advanced technology is called as semantic rule engine based technology.

The Semantic Rules Engine (SRE) [2] that consists of two parts: A rules engine and a semantic engine. The rules engine provides a simple and effective way to deploy a control mechanism (as rules) on gateways. These rules are expressed in a simple scripting language and can be modified and uploaded at run time without disrupting the operation of the gateways. The semantic engine provides absolute abstraction from the heterogeneity

of devices, protocols, data, and any topological changes. It leverages devices metadata and enables the retrieval of contextual information using semantic queries. Inspired from the previous work, leverage a modular approach with a set of common and domain specific ontologies across the enterprise. For instance, a domain ontology capturing one of the industrial automation contexts, is used to annotate the device data with the contextual information, thereby promoting data interoperability and its understanding to users and applications.

### 1.2 MOTIVATING SCENARIO

In industrial manufacturing facility, an energy monitoring solution has been deployed. The solution consists of an IoT gateway and a set of wireless sensors deployed along the industrial manufacturing machines. The IoT gateway collects data from the sensors and pushes it to the remote cloud platform for visualization and analysis. By continuous efforts to maintain green facilities, an internal energy audit concluded the following: Most of the energy waste is occurring in the semi automated industrial process. Energy can be saved by engaging our local personnel working on the industrial process. From this simple scenario, it is clear that the facility manager needs a solution that gives more flexibility to tackle new situations that were not envisioned during the initial setup. The solution needs to be dynamic, flexible, and should not involve any reprogramming or hard reset of the devices. It should also be usable by non-IT experts.

There are two possible solutions: One is to use a tailored solution to solve one problem only and when new requirements arise, reprogram everything again. This option does not scale well and is not suitable to solve new problems or implement new business rules efficiently. The second option is to have a more flexible solution that is easier to implement, does not require reprogramming and supports quick implementation of new business rules.

### 1.3 OBJECTIVE

Design rules to express, deploy, and execute user requirements quickly with time and cost savings and avoiding software development life cycle for every requirement. Install rules on the gateways either locally or remotely through a cloud application. Leverage the ontology concepts to provide consistent, reusable, and shareable view about the data. Rely on a natural language-like grammar to retrieve information from the gateway based on annotated data liberating rules from static unique identifiers. To easily integrate new functionalities and to scale. Finally, the solution should provide dedicated rules execution environment. After a careful study of the state-of-the-art and available open source rules engine, decided to design the SRE to fulfill the required features. The SRE comprises of two parts: The rules engine and an existing work semantic engine. The rules engine provides gateways with the decentralized intelligence and the ability to control or query the connected devices. An Application Programming Interface (API) is provided with SQenIoT that makes it possible for SQenIoT to access the device metadata.

## 2. STRATEGY OF SEMANTIC QUERY BASED INDUSTRIAL AUTOMATION

In the work [1] the automatic control of devices in a smart building systems relies on matching the sensed environment information to customized rules. With development of Wireless Sensor and Actuator Networks (WSANs), low-cost and self-organized wireless sensors and actuators can enhance the smart building systems, but produce abundant sensing data. Therefore, a rule engine with ability of efficient rule matching is the foundation of WSANs based smart build systems. A data annotation architecture [4] is used for the semantic applications in virtualized heterogeneous WSNs. The architecture uses overlays as the cornerstone, and we have built a prototype in the cloud environment using Google App Engine. The early performance measurements are also presented. In industrial facilities, black-box devices are typically used to collect data from variety of devices like sensors, actuators, machines, plants, processes, and systems. Typically these gateways, sample, collect, and push data to a remote platform for further analysis [5] and may also send notifications for certain events. Semantic query engine for industrial internet-of-things gateways [7] they leverage a modular approach with a set of common and domain specific ontologies across the enterprise. For instance, a domain ontology capturing one of the industrial automation contexts, was used to annotate the device data with the contextual information, In the work [9] more dynamic solutions were required that by design offer more flexibility and better control to theses gateways users. The issues like low bandwidth, latency, and security in the industrial domain are additional factors in this. In industrial manufacturing facility, an energy monitoring solution has been deployed. The solution consists of an IoT gateway and a set of wireless sensors deployed along the industrial manufacturing machines. The semantic gateway [18] collects data from the sensors and pushes it to the remote cloud

platform for visualization. Most of the energy waste is occurring in the semi-automated industrial process.

## 3.CIRCUIT DIAGRAM OF SEMANTIC RULES ENGINE

The Fig 3.1 shows the circuit diagram of semantic rules engine. The working of semantic rules engine can be understood from this circuit diagram. The sensors are wired to the Arduino and the raspberry controls the relay. 5v power supply is used for the working of semantic rules engine.

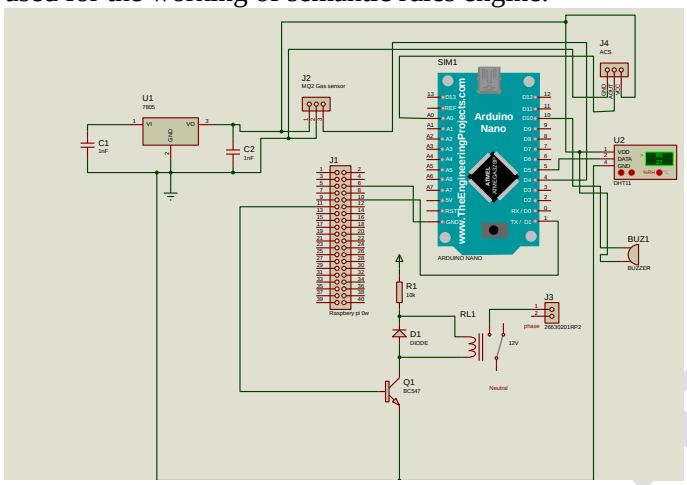



Fig 3.1 Circuit diagram of SRE

**Working Of Semantic Rules Engine**

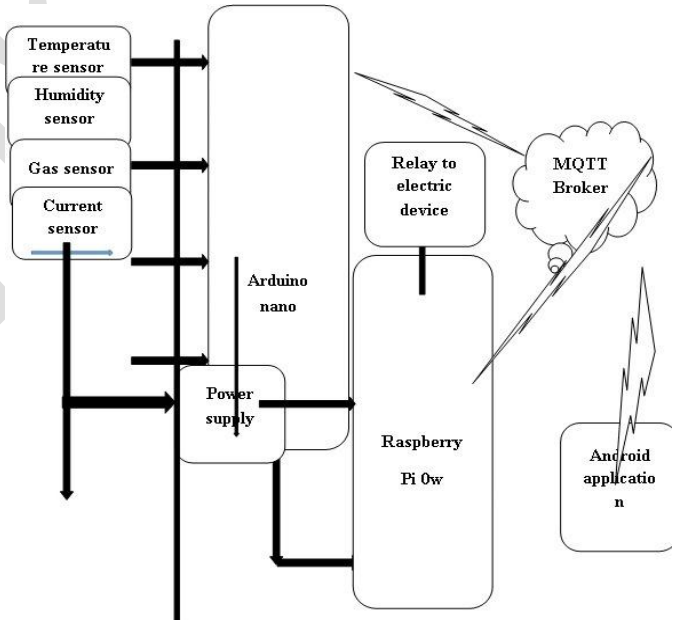
SRE is implemented in the android application as set of predefined queries. First make sure that the Wi-Fi is on and then power on the system. Connect a 5v mobile phone charger to raspberry pi. Rules engine determine the action to be performed by comparing the input from cloud and do specific task to be performed the predefined set of query are the following. Publish or Subscribe Mechanism is done by the MQTT Broker web application. Different login levels for analyse the energy consumption and in industrial level login can control the whole industry. Plot the graphical representations to easily find out the status of energy consumption and from the graph itself it brings the details of the whole industrial energy usage.

**Predefined Queries**:

- Get temperature: display temperature
- Get humidity: display humidity
- Get gas status: display gas status
- Change threshold <value>: eg: change threshold 23
- Relay: relay toggling
- Get relay: display relay status
- Change app: control of relay only to the application
- Change sensor: control of relay to the application as well as the sensor values whenever the command which matches with a particular predefined instruction the corresponding data is published to the MQTT topic to which the Pi is subscribed.
- plot tgraph- plot temperature graph
- plot cgraph- plot current consumption graph
- plot hgraph- plot humidity graph
- Should I increase/decerease temperature?- query for worker
- Show bill details- bill details
- Temp default- set default temperature

## 4. BLOCKDIAGRAM OF SEMANTIC RULES ENGINE

The block diagram of semantic rules engine can be described in the fig 4.2. The sensors are connected to the Arduino and the readings from the sensors published in the web server.



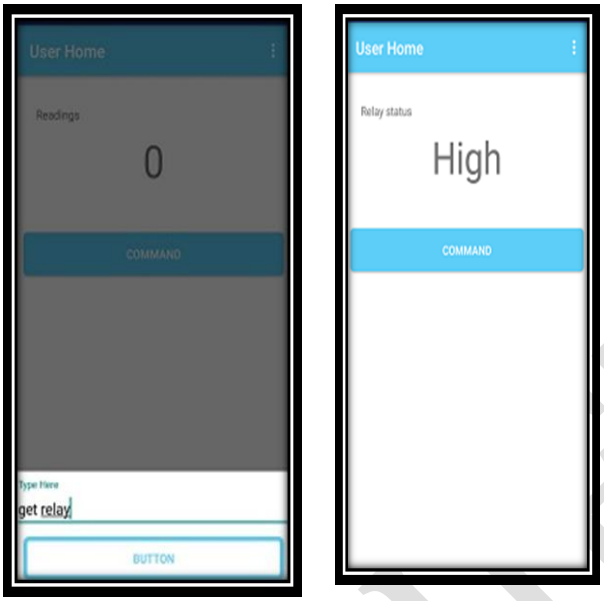

4.1 Block diagram of Semantic Rules Engine

The published readings are subscribed by the android application from the webserver. Raspberry pi is used to control the relay switch and it has the wifi connection and helps to connect the local devices through the wifi connection. All these sensors, microcontroller and Arduino is connected to the power supply and 5v power is used.

## 5. RESULTS AND DISCUSSION

The project aims at the automation of home or an industry. A semantic query feature is added to the system such than an android application is held at the user end with capability of working with predefined commands that are meaningful to

common people and this helps to obtain the sensor data at any instant as well as control the devices at any instant using these predefined commands that could be given as text input to the application. Also threshold of sensors used in automation could be set via android application and thus provides changes in the working condition of the system. This automation brings out optimized energy consumption and continuous monitoring of the system. Iot is used to connect the system to internal using MQTT protocol. Here the method was implemented by an android application with the support of C language.

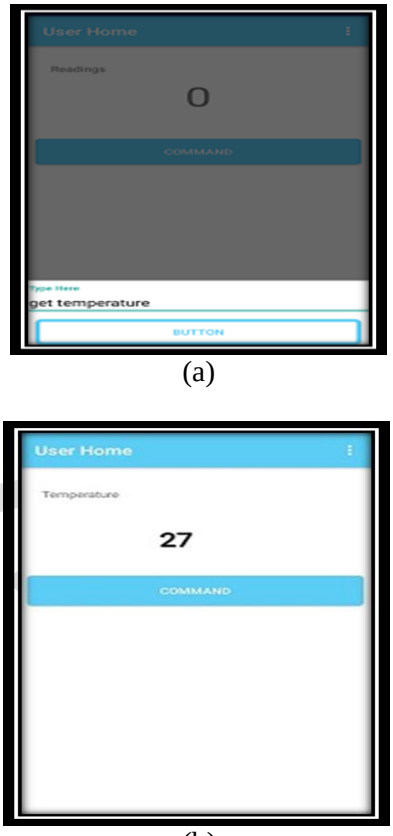



(a) (b)

Fig 5.1 Check the connection of system whether relay is on or off.

Fig 5.1 represents the relay representation and the connection between the system and the control panel. If it is high the connection is good and low means the connection is poor.After the connection verification the next step is to find the temperature, humidity and gas using the corresponding sensors. There is a window displays with readings zero, and there is an option called command button. By clicking this command button displays a new window and can type the command called get temperature and it dsiplays in the Fig 5.3. By using this command get the readings of temperature. Instead of get temperature command can type get humidity shows in Fig 5.4, get gas to find the current status of gas shows in Fig 5.5.

Temperature and Humidity is in the celcius temperature format and the gas leakage is detected by the MQ2 gas sensor. If the gas is leaked then it displays leakage is detected otherwise it states as normal.




(a)

(b)

Fig 5.3 To find the Temperature (a) Command Button (b) Output Display

The temperature value is displayed in the degree celsius form and from this can calculate the farrenheat form. This is same as in the case of humidity values. Doing many callibrations only can read the values of humidity and temperature.

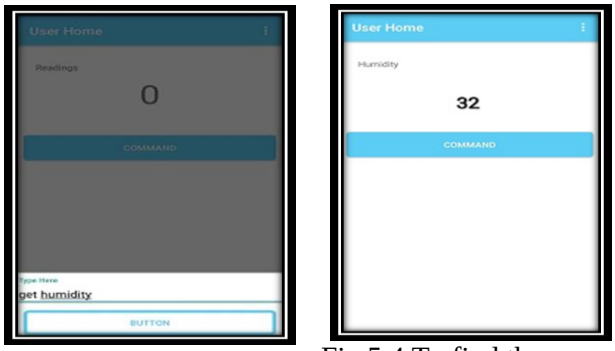



Fig 5.4 To find the Humidity

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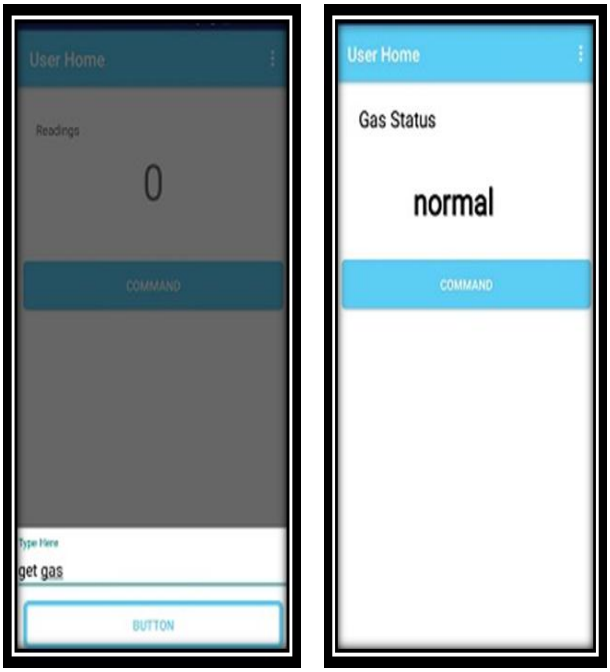
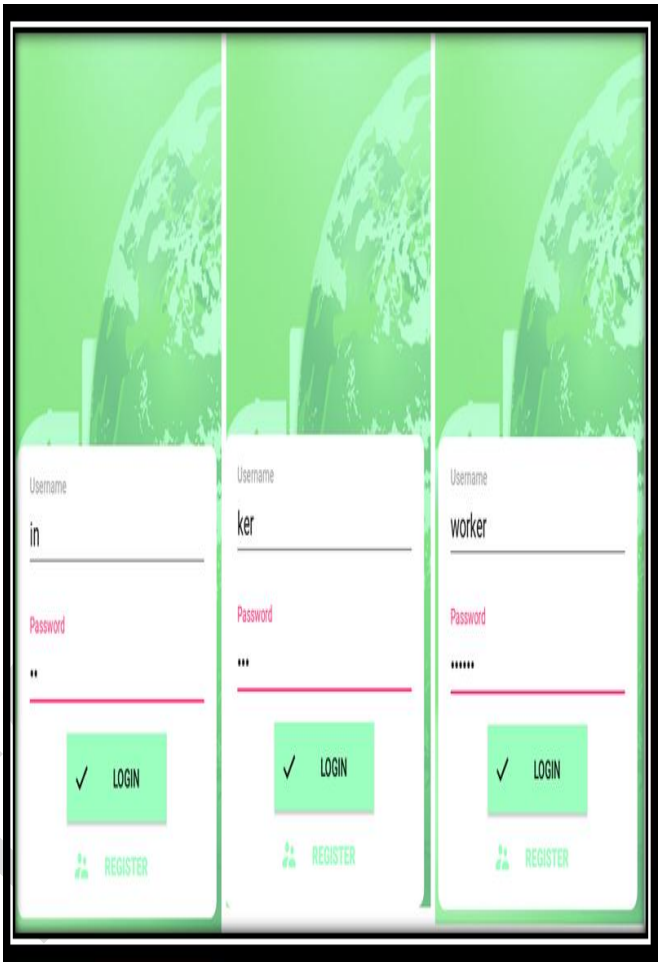



Fig 5.5 To find the status of Gas

This is the results displays by using the industrial automation with the help of semantic rule engine. In raspberry pi in pin 7 represents the gas input pin 3 represents the DHT input and in pin 0 shows the relayed output.

Three levels of login access is enabled in the application to analyse the energy consumption using SRE. Three authorites can be access the web page using different loginlevels. The national authority can view the details of industry which the energy consumption is high and also analyse the graphical details given by the industry. The state authority can check the details of graphs that produced during energy consumption. The industrial authority can control the whole industry (electrical devices) and also has the power to switch on or off the relay status. Fig 5.6 represents the above explanations. Fig 5.7 shows the state level authority can check the details of an industry how much energy usage was done by a fixed period of time and it helps to identify where the energy is wasted and also make some precautions to the next level usage and it helps to control it.




(a) (b) (c)

Fig 5.6 Different Login Levels (a) National Level (b) State Level (c) Industrial Level

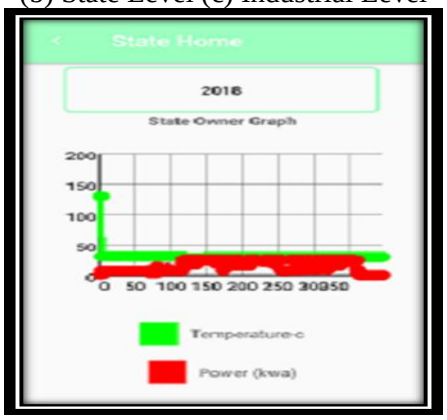



Fig 5.7 State owner graphical representation of temperature and humidity

By asking any queries about the current temperature in an industry or any worker can ask the normal temperature level of a particular device then the SRE gives the correct solution to the respective query. This is why it says that the SRE doesn't need any human support. If the worker is not familiar with the engineering section of the industry can also

handle the situation as well. Fig 5.8 shows the output of a query.


Fig 5.8 Query output

The Fig 5.9(a) represents the graphical representation of temperature that produces at the time of manufacturing in an industry. From these graphs which identifies the temperature level, energy consumption means, where the energy is wasted, which device takes the energy most and also which industry used the current more. This analysis is done by different login levels. The industrial authority can check the proximate details of the devices, state level authority can check each units in an industry and at last the national level login finds which industry takes the energy more.

Here in temperature production graph which indicates an X and Y axis. In X axis represents the time interval and Y axis represents the degree celsius measurement.

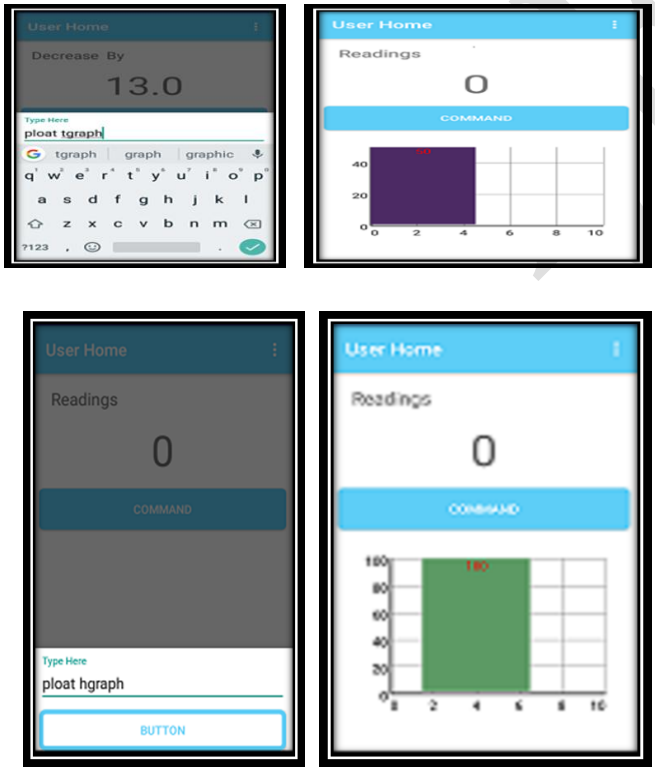



Fig 5.9(a) Graphical representation of temperature

Likewise in humidity measurement and current consumption measurement also graphical representation can be visible by the corresponding authorities.


Fig 5.9(b) Graphical representation of humidity

Humidity measurement is very essential in the industry, because the moisture content in the air badly affects the devices in an industry. So the authorities should responsible for the control of the humidity or moisture content inside the industry.

Fig 5.9(c) graphical representation of current consumption

## 6. CONCLUSION

The SRE have a capability to control the whole industry with the support of semantic queries. Rule based technology is done by the industry to easily find out the problems and make the solutions. Different level login authority can be done for analysing the current situation and energy consumption of the industries. National level login has been identifies the which industry takes the energy most. The semantic engine allows access to devices using the semantic tags. Rules are defined by simple language to easily identifies the situation by an ordinary man. The relation between semantic engine and rules engine has been successfully created with low cost. The main advantage of this rules are remain valid when any other devices will be added or removed. It's a very simple process having industrial gateways to transfer the datas using semantic queries. Utilizing hardware and software automation increases productivity, safety and profitability. Semantic rule engine can also result in enhanced quality, precision and accuracy, it involves the various control systems operation that enable operating equipment to run on their own, speed for

tasks and many more. It handles different processes and machineries in an industry to replace a human being. It is the second step beyond mechanization in the scope of industrialization. The work in this paper is tested, validated and implemented and also have been used to extend the study for several other works.

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