



# A STUDY INTO THE FEASIBILITY OF CONSUMERS TRIGGERING FACTORY ROBOTS TO START PRODUCTION OVER THE INTERNET TO OPTIMIZE THE CURRENT PURCHASING SYSTEM

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## ABSTRACT

This paper aims to study and justify the feasibility of developing a more efficient purchasing system due to the inefficiencies in the current system which is an economic waste and source of global warming. Today if products are not sold they are dumped by supermarkets, wholesalers, warehouses and factories. All this happens because of incorrect demand predictions. But if products are manufactured only after their credit cards has been debited there will not be a problem of incorrect demand prediction all along the supply chain. This will lead to a purchasing system where customers deal directly with factories, which is favorable to producers as well as customers because cost will go down and wastages will reduce.

**Keywords:** *Factory Robots and Purchasing System.*

## 1. Introduction

Systems are currently available, whereby as soon as a customer, somewhere in the world credits money for a product, humans and software processes this orders and gives instructions to other humans in factories to produce the product. Many high technology factories mine data from the likes of Google, Facebook and Twitter to predict demand levels [1]. An improvement to such a system is to get the robots to manufacture the product as soon as the money is credited from customers' credit cards.

The reduction of wastage all along the line from supermarkets to factories plus the lean system whereby factories deal directly with customers will result in cheaper products for everyone. There will be no need to predict demand levels thereby negating the need for predictive models for the demand structure provided by the likes of Google, Facebook, Twitter etc. Eventually only advertisers and trend builders will be needed to promote products. Today the biggest obstacle in achieving such a system is security issues. If hackers can hack into factories and start making robots perform wrong tasks, production will be jeopardized. Therefore security software must be developed or sourced from experienced anti-virus software developers, the likes of McAfee to couple with such a system.

## 2. Litreature Review

If two computers are connected to the same router, with the first (server) also connected to a PLC (Programmable Logic Controllers), GE (General Electric) WebView enables triggering the PLC from the second computer. But bringing this concept one step further, which is to trigger the PLC from a computer on the other side of town over the internet requires the factory to have a dedicated static IP address leased from the ISP (Internet service provider). This is costly and in some cases the ISP may not have IP address available for lease.

One way to get around this is to use Dynamic Domain Name Service (DDNS) through a provider like DynDNS.com (there are also other providers like TZO and DMOZ). This service is able to dynamically update DNS information as the IP address changes occur on the router. Most modern routers have built-in DDNS clients that support this function. Say a router is connected to a laptop and this laptop is connected to a PLC which controls robots in a factory. Upon signing to the DynDNS service provider, it keeps track of the changes in the public IP address of the router. On the DynDNS account, one can also define an available URL to point

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to the Public IP address of the router being used for this experiment. As an example an available name is <http://UNIMASfms.dyndns.com>. Individual devices on the local LAN including the server laptop used in the experiment can be assigned a port number using port translation done on the firewall. The firewall can be an independent device or may be bundled as a service within the router. For this example one can assign port 5000 to the internal IP address of the server laptop, so by typing: [www.http/unimasfms.dyndns.com:5000](http://www.http/unimasfms.dyndns.com:5000), one can access the server laptop from another country [2].

In a typical small business or home router there are many services that are bundled into it. Some of these are: Domain Name Service (DNS), Dynamic Host Configuration Protocol (DHCP) server and the Firewall service. The DNS server translates human readable domain names into IP addresses; for example, [www.unimas.com.my](http://www.unimas.com.my) is translated to 124.82.253.238 using Internet Protocol Version 4 (IPv4). But even that string of decimal numbers are meant to be human legible. The final transmission is a string of binary numbers. The new protocol currently being implemented is Internet Protocol Version 6 (IPv6) which changes the name to a longer string of hexadecimal numbers designed to cater for the ever increasing IP addresses cropping up in the world [3].

The DHCP server software is explained as follows; when any network device starts-up and if it does not have a static IP address assigned, it will send out a broadcast using its MAC (Media Access Control) address for an available DHCP server. When the available DHCP server identifies itself, it will send a query to request for the device's MAC address. On receiving this information, the DHCP server will proceed to lease an available IP address to the device. Beyond the router the DNS server translates the Private IP address to a Public IP address [4].

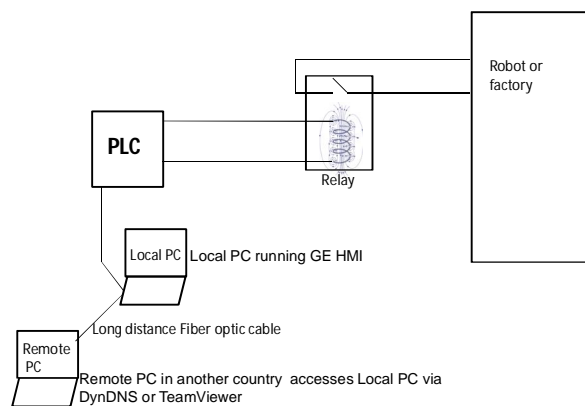
The Firewall server acts as a gate to filter out rouge software and IP addresses from accessing the laptop. So if 168.74.5.4.2 is the IP address of the PLC server or hub that controls the robots, the Firewall server software has to be modified such that the connection from outside to this PLC is allowed.

Another important software that resides in a typical router is the DDNS client. The DDNS client informs service providers like DynDNS what its latest IP address is. These providers provide this simple service for free but for similar services with more features, a payment must be made. To view the list of IP addresses for a computer the command, "ipconfig" must be typed in the DOS screen. The DOS screen appears after clicking Start then Run and typing "cmd". It can be noticed that the Default gateway, the DHCP server and the DNS server has the same IP address,

because all resides in the same router. The process of pinging is done to determine a device or website responding to a call. Ping google.com means sending a "hello" to Google and waiting for a response. There is always a standard of four replies from the pinged website.

### 3. Methodology and Results

A relay circuit is needed to connect the PLC to the robot as shown in Figure 1. This form of circuitry serves two functions, one is to protect the PLC and the robot and the other is to overcome the differences in output signals of the PLC and the input signal acceptable to the robot. Some signals are sourcing (for example +24V and -24V respectively).

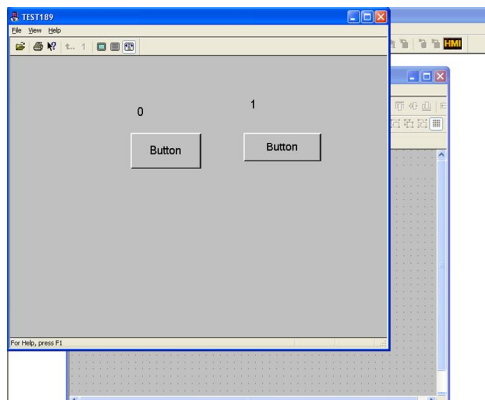


**Fig. 1 Schematic Depicting the System for Remote Ordering of Products**

The GE HMI (Human Machine Interface) helps visualize and control the whole factory. It also has an ability to collect data and sent it to applications that can analyze statistical trends in the production process which often help in deciphering a root cause of problems, thus enabling the removal of these defective products at a faster rate. The defects in products from factories can range from contamination, the wrong habit of some factory workers, electrical problems and mechanical wear-and-tear of machine parts. Thus this HMI allows an operator or engineer to make decisions based on the visual data on the computer screen and also crunch data with a statistical software. There is a built-in software called Historian which enable factory staff to go back in time to find the starting point of a defect in products, even from a home, as long as they have the password access. In observations of the operation of the Western Digital factory in Kuching, Malaysia, one can

see that if data is viewed at different angles, that is, plotting the charts of parameters (different chemicals, human protocols or machine mechanical process values) to final yield, root caused can be discovered. The GE HMI enables this, as various views of the production trends can be plotted even during a meeting of engineers compared to the way it is done in Western Digital's Kuching, Malaysia factory where engineers have to come back for another meeting after the numbers are crunched by a human using Excel spreadsheet. With the GE HMI even the robots can be adjusted in the meeting, over a computer screen to solve some production problems. This HMI can support many hundreds of servers running various portions of a big process [5].

The initial project was to use the GE built-in function to trigger the PLC remotely. This was successfully done as follows. The laptop was connected to the PLC and the GE HMI was used to build a virtual button. This virtual button was programmed to trigger the PLC. The next step is to create a software setting which will turn the laptop into a server. Then from a remote computer, Google Chrome browser was opened and an address, in this case, the address is <http://192.168.1.3:8080> was typed in the address bar. The remote computer connects to the laptop server albeit a bit slowly as it starts up, but later the response time is immediate. From the remote computer the same virtual button can be seen and toggling this button with a mouse as shown in Figure 2, toggles the appropriate output pin on the PLC. The toggling of the PLC from the remote computer happens immediately with no human detectable delay. But this remote computer is also connected to the same router.



**Fig. 2** As the buttons above are clicked in the GE HMI the respective output # 4 is toggled in the PLC

Triggering the PLC from a different place was performed, and it was unsuccessful. The reason for this

is the requirement of a static IP address from the internet service provider. This is because bigger router above the small router in the internet network, named DNS is programmed to change the router's IP address randomly. A static IP address will enable the router to have a permanent address. This will then enable triggering the PLC from another part of town or from another country; effectively enabling customers to trigger factory robots in another country to produce a product. However these private IP addresses are quite expensive and must be justified by a high factory production output rate to cover its cost [6].

Alternatively a "virtual private IP address", can be step up by registering with [www.DynDNS.com](http://www.DynDNS.com). Then a host name must be created by choosing the options, "Host Services" and "Add Host". The next step is to log into the router connected to the laptop and configure DDNS with the same username and password previously set in the DynDNS.com. Then a port must be created with forwarding rules in the router to point the port (typically 5000 and over) to the internal IP address of the laptop, typically 192.168.1.10. Thenceforth when accessing the router from another country for example, the address typed should be like <http://mypc.dydns.com:5000> [7].

Another approach is to use a remote control service from entities like, TeamViewer and Logmein but these services are potentially more prone to attacks by hackers. More protections software must be built on top of TeamViewer before it can be utilized as a product ordering system. TeamViewer enables remotely connecting to the server computer directly from another country and from there controlling the PLC. This is just like the software used by the GE representatives in China to help in this work. The GE China representative remotely controlled this researcher's laptop in Kuching, Malaysia from his office in Shanghai, China. The GE China representative can see the full screen of this research computer and thereby control the PLC hub. This means he can also control a factory of robots connected to the PLC hub. The TeamViewer website is very intuitive; therefore setting up the laptop to use this freeware is easy. For a customer to actually utilize a TeamViewer type software, a logic flow can be; after the money has been credited with a credit card, an in-between computer will automatically key in the product specification into the factory's server computer (assuming located in another country), and this will directly instruct the robots to manufacture the required product.

A test was performed using the TeamViewer software, and it remotely (from another part of the town) connected to the server laptop and toggled the PLC

which also means triggering a robot to do a sequence of operations is possible or a whole factory of robots

Once the testing and updating of the HMI screen is finalized, the username and password can be changed. If the PLC output screen toggles on clicking the button on the screen, the software is working well. The next step is to draw all machines, levers and switches on the screen to represent the factory.

The GE HMI is one of the advantages of the GE PLC compared with other common PLCs. Most other PLC software just control the PLC and a separate HMI normally comes with the touchscreen. The GE HMI is bundled together with the PLC software. Thus instead of controlling only the PLC with the software, a whole HMI can be built with the GE PLC software (Proficy HMI SCADA CIMPLICITY 7.5 Workbench). The software can be running on a laptop and this can control a whole factory. This is compared to the installation in the Western Digital (WD) factory in Kuching, Malaysia where a touchscreen plus HMI cost about USD2,164 each and there are 64 machines requiring this. This has to be bought in addition to the Mitsubishi PLC which controls the process machine. Thus for 64 machines the HMI modules cost adds up to about USD421,052. Comparatively with a GE HMI software running on a standard PC can control 64 machines at a cost of just 2% of what WD spent for the HMI system. In addition the GE Cimplicity replaces the software that is dedicated to acquisition of historical data of events that occurred in the production machines. This will enable easy performance of statistical analysis of the data and thereby ease the production troubleshooting process.

#### 4. Conclusion

The ability to control a PLC over the internet implies the ability to transform customer's purchase orders immediately into products. This was successfully demonstrated in this work. There is not much literature review on this probably due to the vested interest in the current purchasing system. The middlemen who get from 30% to 300% markup will not be interested in factories dealing directly with customers. Companies like Amazon have already developed systems where customers trigger actuations in warehouse to start moving products but not to initiate factory robots to produce products. Another notable company that is striving to cut out middlemen is DELL, which sells many of its products directly to customers but still uses humans in-between to process the order. This paper envisages customers who have credited their credit cards triggering factory robots thus greatly reducing wastage in the current purchasing system. But

more security software needs to be built on top of this software to enhance security. This is because, if the keystrokes of customers half across the earth can get the robots to function in a factory, rouge customers may also try to hack into the software to destroy the robots either for the thrill of doing this or due to business rivalry. With middleman between factories and customers gone, there will be a big increase in efficiency of the purchasing system which will reduce product cost and also reduce global warming as there will be no build up of products due to inaccurate demand prediction.

#### 5. Future Work

More research needs to be done on the feasibility of protecting robots in factories from outside attack online. PLC was always immune from rouge attacks till the Bashir nuclear plant's (in Iran) Siemens PLC was attacked. A first of its kind PLC virus was somehow planted in the Siemens PLC that controls the plant. Therefore all big systems like huge oil and gas establishment are now installing PLC anti virus protection. Probably McAfee already have solutions to these problems thus researchers do not need to reinvent the wheel.

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