

Is It Time to Introduce Virtual Logic Solvers in the Process Industry?

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Independent Logic Solvers for BPCS and SIS – Would you make one or both Virtual ?



Aim

- Study the reliability of taking Logic Solvers of Basic Process Control System (BPCS) and/or Safety Instrumented Systems (SIS) on cloud and make them virtual.
- The reliability study involves evaluating feasibility of the system by assigning scores/ranks and weightages to different parameters and considering the highest score for judging the system.

Work done so far

- The study was carried out by considering pros & cons of six different scenarios. The scenarios were based on the extent of integration of wireless network into the plant.
- Starting with the first scenario using conventional controllers and ending with the last scenario with IIoT wireless devices in the field and BPCS / SIS logic solver on the cloud.
- Failure Mode and Effects Analysis (FMEA) was carried out for Scenario 3.

Background

- Both BPCS (Basic Process Control Systems) like DCS (Distributed Control Systems) and SIS (Safety Instrumented Systems) have evolved in the past few decades.
- Starting from Pneumatic instrumentation to Single Electronic Control Loops, the concept of DCS came up in the 1970's. The idea was to have all the control loops and interlocks controlled and managed at one place, the DCS controller (Scenario 1).
- To make it more cost effective and Elegant during Engineering and configuration Universal IO and later Remote IO was introduced between 2000 and 2010 (Scenario 2 and 3).
- Between 2010 and 2020, the concept of IIoT (Industrial Internet of Things) started gaining momentum, with Switch hubs in the field or LER (Local Equipment Rooms) and a Router in the main Control room with CAT5 cables between them.
- 2020 onwards, carrying out feasibility study of having the Controller on the "Cloud" Both for BPCS and SIS.

Parameters evaluated for assigning scores

- 1. Ease of Engineering and Design
- 2. Ease of Operation and Maintenance (O&M)
- 3. Project cost
- 4. O&M cost
- 5. Effects due to Human error
- 6. Cyber threats and effects
- 7. Human skill requirement
- 8. Controller Computational power
- 9. Supply chain efficiency
- 10. Integration of systems

Scenario 1 – Conventional BPCS (or SIS) systems



Ref : https://automationforum.co/what-is-a-junction-box-and-its-applications/

Features :

- "Point to Point" cabling
- Extensive Engineering and installation work
- Lots of components
- Longer project duration
- Less ease in Operation and Maintenance

| Parameters | Advantage weightage (1 to 5) in ascending order | Advantage points (1-10) in ascending order | Total Advantage points |
|--|---|--|------------------------------|
| Ease of Engineering and Design | 4 | 4 | 16 |
| Ease of Operation and Maintenance (O&M) | 4 | 2 | 8 |
| Project cost | 5 | 3 | 15 |
| O&M cost | 5 | 1 | 5 |
| Effects due to Human error | 5 | 5 | 25 |
| Cyber threats and effects | 5 | 5 | 25 |
| Human skill requirement | 5 | 8 | 40 |
| Computational power | 4 | 8 | 32 |
| Supply chain efficiency | 5 | 5 | 25 |
| Integration of systems | 4 | 6 | 24 |

Scenario 2 – BPCS (or SIS) with Universal IO modules



Ref: https://automationforum.co/what-is-a-junction-box-and-its-applications/

Advantages:

- Reduction in number of IO modules
- Allows last minute changes in Engineering
- Flexibility in homerun cables

| Parameters | Advantage weightage (1 to 5) in ascending order | Advantage points (1-10) in ascending order | Total Advantage points |
|--|--|---|------------------------------|
| Ease of Engineering and Design | 4 | 5 | 20 |
| Ease of Operation and Maintenance (O&M) | 4 | 3 | 12 |
| Project cost | 5 | 4 | 20 |
| O&M cost | 5 | 2 | 10 |
| Effects due to Human error | 5 | 5 | 25 |
| Cyber threats and effects | 5 | 5 | 25 |
| Human skill requirement | 5 | 8 | 40 |
| Computational power | 4 | 8 | 32 |
| Supply chain efficiency | 5 | 5 | 25 |
| Integration of systems | 4 | 6 | 24 |

Scenario 3 – BPCS (or SIS) with Remote Universal IO modules in the field



Ref : https://automationforum.co/what-is-a-junction-box-and-its-applications/

Advantages :

- Elimination of conventional Field Junction boxes and home run multicore cables
- Lesser equipment in control room
- Late design and more design flexibility

| Parameters | Advantage weightage (1 to 5) in ascending order | Advantage points (1-10) in ascending order | Total Advantage points | |
|--|--|--|------------------------------|--|
| Ease of Engineering and Design | 4 | 6 | 24 | |
| Ease of Operation and Maintenance (O&M) | 4 | 3 | 12 | |
| Project cost | 5 | 5 | 25 | |
| O&M cost | 5 | 3 | 15 | |
| Effects due to Human error | 5 | 6 | 30 | |
| Cyber threats and effects | 5 | 5 | 25 | |
| Human skill requirement | 5 | 8 | 40 | |
| Computational power | 4 | 8 | 32 | |
| Supply chain efficiency | 5 | 5 | 25 | |
| Integration of systems | 4 | 6 | 24 | |

Scenario 4 – BPCS (or SIS) with Remote UIO and Controller on the Cloud



Effects due to Human error

Cyber threats and effects

Human skill requirement

Computational power

Supply chain efficiency

Integration of systems

5

5

5

4

5

4

7

3

6

6

6

7

35

15

30

24

30

28

Advantages:

- Flexibility of controller being accessible from anywhere, easy configuration, updates etc.
- Eliminating conventional Field Junction boxes and home run multicore cables
- Lesser equipment in control room
- Late design and more design flexibility

Ref: https://automationforum.co/what-is-a-junction-box-and-its-applications/

Scenario 5 – BPCS (or SIS) with IIoT devices in the field and Controller on the Cloud



lerror

effects

Human skill

requirement

Cvber threats and

Computational power

Supply chain efficiency

Integration of systems

5

5

4

5

4

2

5

6

8

8

10

25

24

40

32

Advantages:

- Industrial Internet of Things (IIoT) devices in field.
- Flexibility of controller being anywhere, easy configuration, updates etc.
- Eliminating home run multicore cables but only CAT5 cables and Switches.
- Lesser equipment in control room.
- Late design and more design flexibility.

Scenario 6 – BPCS (or SIS) with Wireless IIoT devices and Gateway in the field, Controller on the Cloud



Disadvantages:

- Cyber attacks
- Human skill is required to operate cloud based system
- Computational power required for controller
- Battery life of field equipment

| Parameters | Advantage weightage (1 to 5) in ascending order | Advantage points (1-10) in ascending order | Total Advantage points | |
|--|--|--|------------------------------|--|
| Ease of Engineering and Design | 4 | 9 | 36 | |
| Ease of Operation and Maintenance (O&M) | 4 | 7 | 28 | |
| Project cost | 5 | 9 | 45 | |
| O&M cost | 5 | 8 | 40 | |
| Effects due to Human error | 5 | 7 | 35 | |
| Cyber threats and effects | 5 | 1 | 5 | |
| Human skill requirement | 5 | 5 | 25 | |
| Computational power | 4 | 6 | 24 | |
| Supply chain efficiency | 5 | 8 | 40 | |
| Integration of systems | 4 | 8 | 32 | |

Advantages:

- Wireless devices in the field, easy to install
- Minimal cabling in the field
- Flexibility of controller being anywhere, easy configuration, updates etc.
- Eliminating home run multicore cables and field JBs
- Lesser equipment in control room
- Late design and more design flexibility
- Emergency Shutdown System designed independent of equipment

Ref: https://automationforum.co/what-is-a-junction-box-and-its-applications/

Summary - Cable schedule

| Scenario | Field Instruments to JB | Field Instruments to remote IO | JB to Marshalling cabinet in Control Room | Marshalling cabinet to IO cabinet | IO (or Remote IO) cabinet to Controller | Remote IO cabinet to Cloud |
|----------|-------------------------------|--------------------------------------|--|--------------------------------------|--|---|
| 1 | 2 core cable | | Multicore cable | Pre-Fabricated system IO cables | System provider specific | |
| 2 | 2 core cable | | Multicore cable | Pre-Fabricated system IO cables | System provider specific | |
| 3 | | 2 core cable | | | CAT 5 cable to controller via Switch & Router | |
| 4 | | 2 core cable | | | | CAT 5 cable to controller via Switch & Router/FW |
| 5 | | CAT 5 cable | | | | CAT 5 cable to controller via Switch & Router/FW |
| 6 | | No cables | | | | CAT 5 cable to controller via Router / FW |

Results

| Scenario # | Scenario description | Total Advantage points | Ranking based on Total Advantage points |
|------------|--|------------------------------|---|
| 1 | Conventional BPCS (or SIS) systems | 215 | 6 |
| 2 | BPCS (or SIS) with Universal IO modules | 233 | 5 |
| 3 | BPCS (or SIS) with Remote IO modules | 252 | 4 |
| 4 | BPCS (or SIS) with Remote IO and Controller on the Cloud | 261 | 3 |
| 5 | BPCS (or SIS) with IIoT devices and Gateway and Controller on the Cloud | 293 | 2 |
| 6 | BPCS (or SIS) with Wireless IIoT devices and Gateway and Controller on the Cloud | 310 | 1 |

FMEA (Failure Mode and Effects Analysis) for scenario 3

| Components | Severity score | Frequency of occurrence | Frequency | Severity * Frequency | Risk |
|--|-------------------|-------------------------|-----------|-------------------------|------|
| Universal I/O modules | 7 | once in 10 years | 0.1 | 0.7 | 2 |
| Controller | 7.25 | once in 10 years | 0.1 | 0.725 | 1 |
| Ethernet cables & switches | 5.75 | once in 10 years | 0.1 | 0.575 | 4 |
| Homerun cables (cable tray system) | 6.6 | once in 50 years | 0.02 | 0.132 | 5 |
| Field control valve | 6.5 | once in 10 years | 0.1 | 0.65 | 3 |
| Field sensors | 5.75 | once in 10 years | 0.1 | 0.575 | 4 |

- Risk is based on the product of severity score and frequency of occurrence divided by the number of potential failure modes considered for each component.
- Controllers have the maximum risk while homerun cables possess minimum risk.
- The study supported the results obtained from the evaluation of pros & cons of all the scenarios.

Future work

- Carry out Failure Mode and Effects Analysis for all the scenarios and check the feasibility of putting the safety system controller on the cloud.
- In addition, testing the controller on a VM/cloud infrastructure for a pilot plant and continuously collect data to carry out Reliability studies.



Questions?