

Traffic Types & their Mapping to TSN Mechanism

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Background

To clarify queue set-up and TSN configuration, this contribution shows detail of traffic stream specifications for a system based on our last Bangkok meeting consensus.

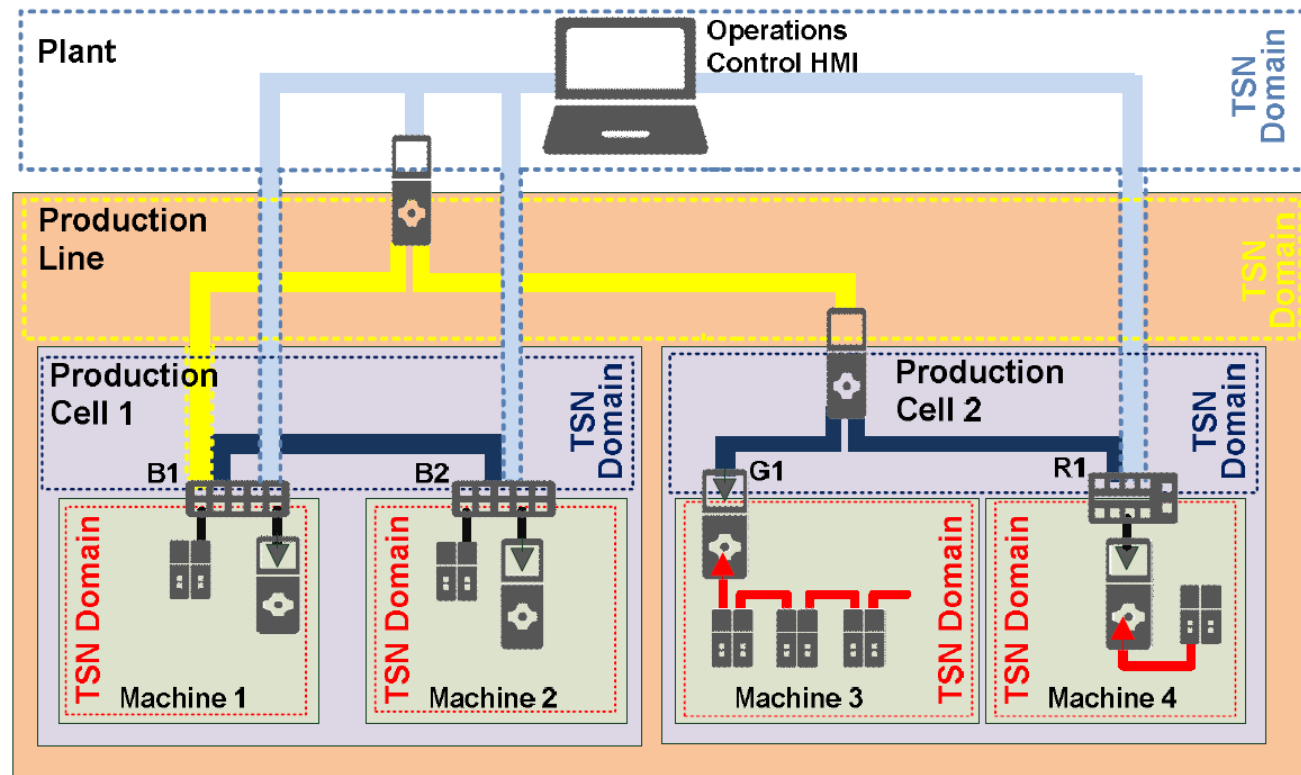
Outline

1. Base use case
2. System components, connection, streams
3. Traffic type and traffic class
4. Queue setup and TSN configuration for constrained bridge
5. Conclusions

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M2M use case (U-17)



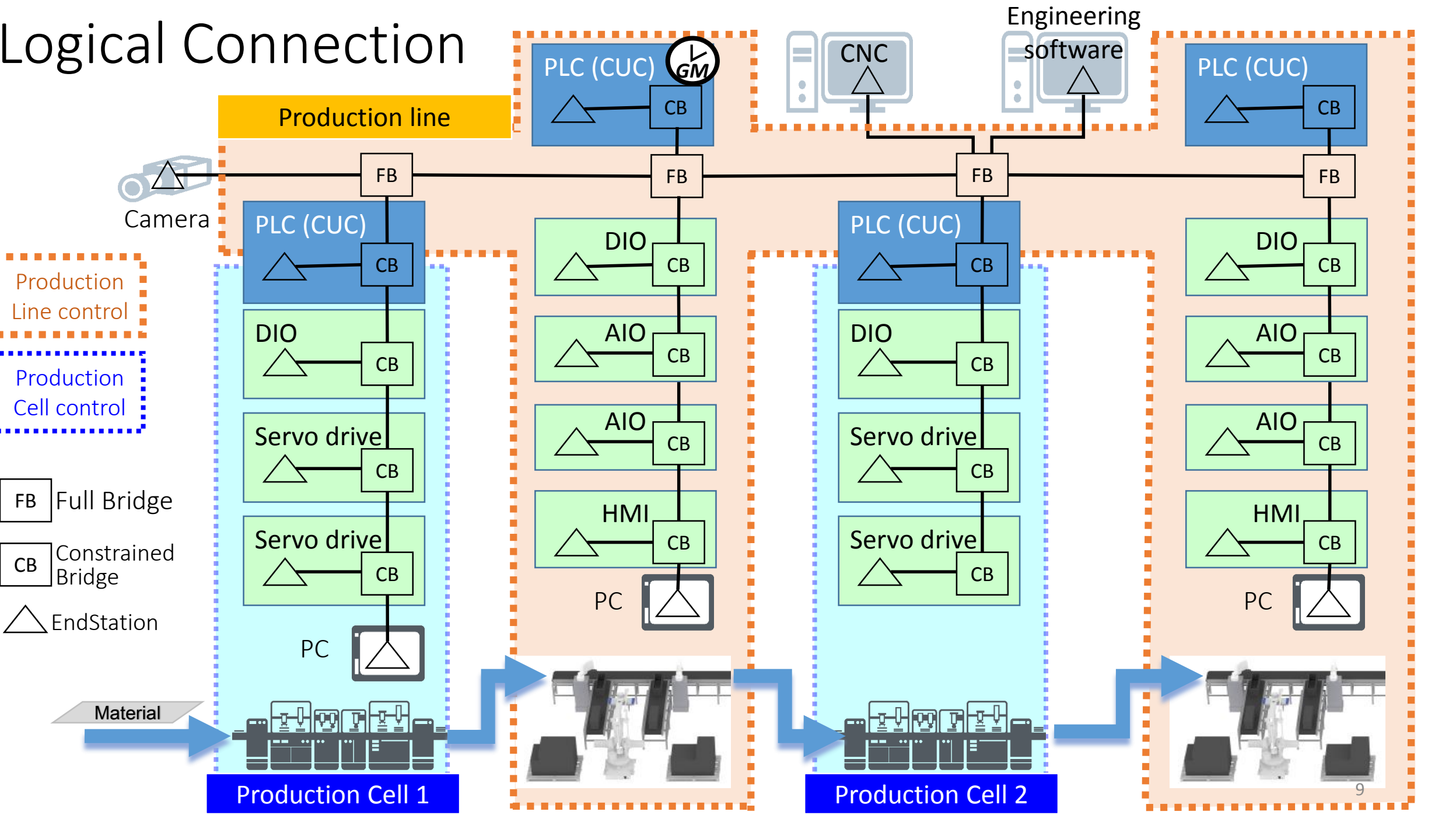
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System Components

- CNC
- CUC in PLCs
- Devices for Production Line
- Devices for Production Cells
- Engineering software workstation
- Grand master in PLC
- IP video camera
- PC for Production Line/Cell monitoring

Logical Connection



Streams in this system

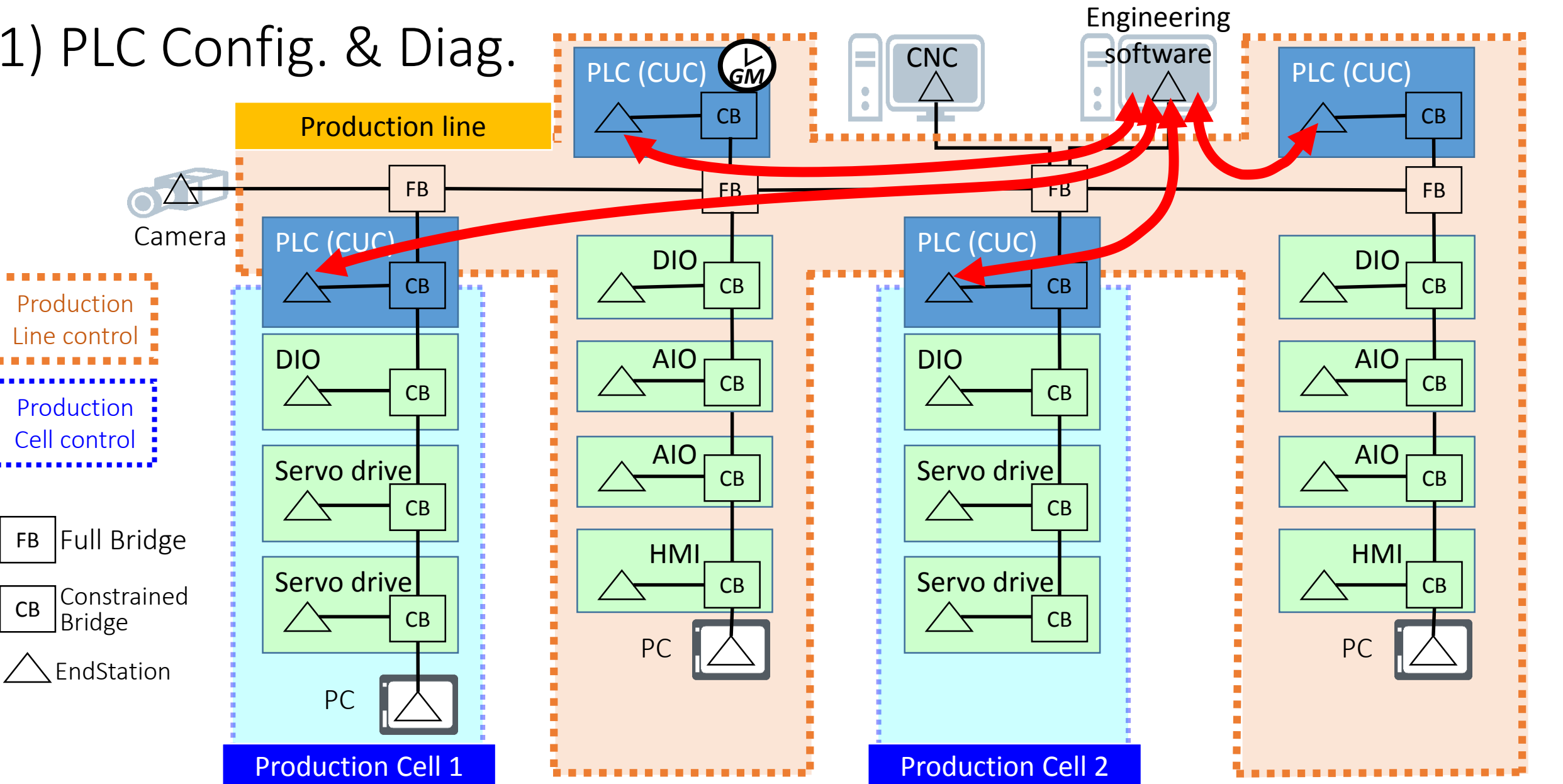
- 1) Streams for **PLC Config. & Diag.**
- 2) Streams for **FB/CUC Config. & Diag.**
- 3) Streams for **Production Line control (Controller-Controller)**
- 4) Streams for **Production Line control (IO control)**
- 5) Streams for **Production Cell control (Motion control)**

Streams in this system

1) Streams for **PLC Config. & Diag.**

(a) Sporadic communication between Engineering software and PLC

1) PLC Config. & Diag.



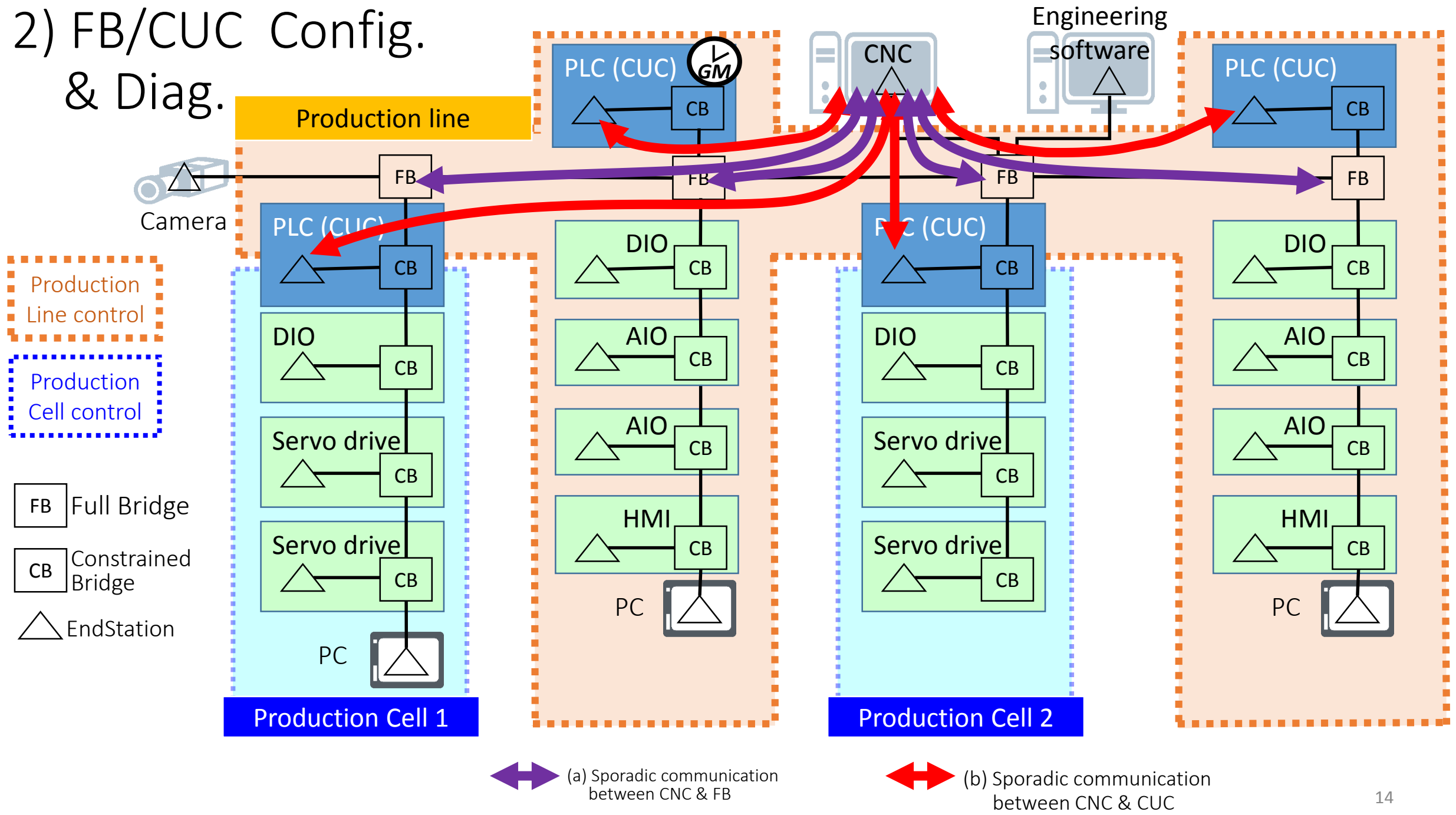
Sporadic communication between Engineering SW & PLC

Streams in this system

2) Streams for **FB/CUC Config. & Diag.**

- (a) Sporadic communication between CNC and FB, including LLDP
- (b) Sporadic communication between CNC and CUC in PLC

2) FB/CUC Config. & Diag.

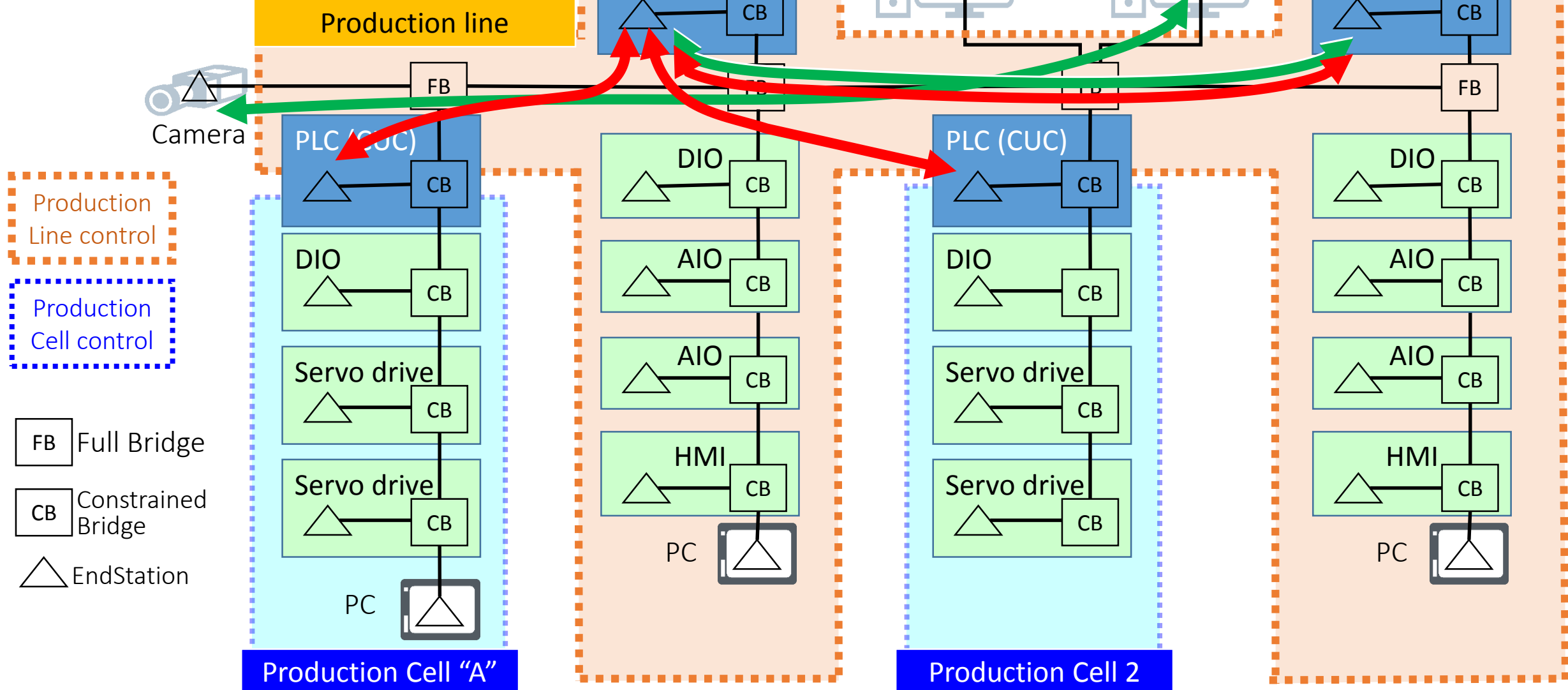


Streams in this system

3) Streams for **Production Line control** **(Controller-Controller)**

- (a) Periodic communication for Time synchronization
- (b) Cyclic communication between controllers
- (c) Sporadic communication for Config. between CUCs in PLC
- (d) Sporadic communication for Diag. between PLCs
- (e) Sporadic TCP/IP communication with PLCs etc.
- (f) Bursty UDP/IP communication with Camera etc.

3) Production Line Control (Controller-Controller)



FB Full Bridge
 CB Constrained Bridge
 EndStation

Production Cell "A"

Production Cell 2

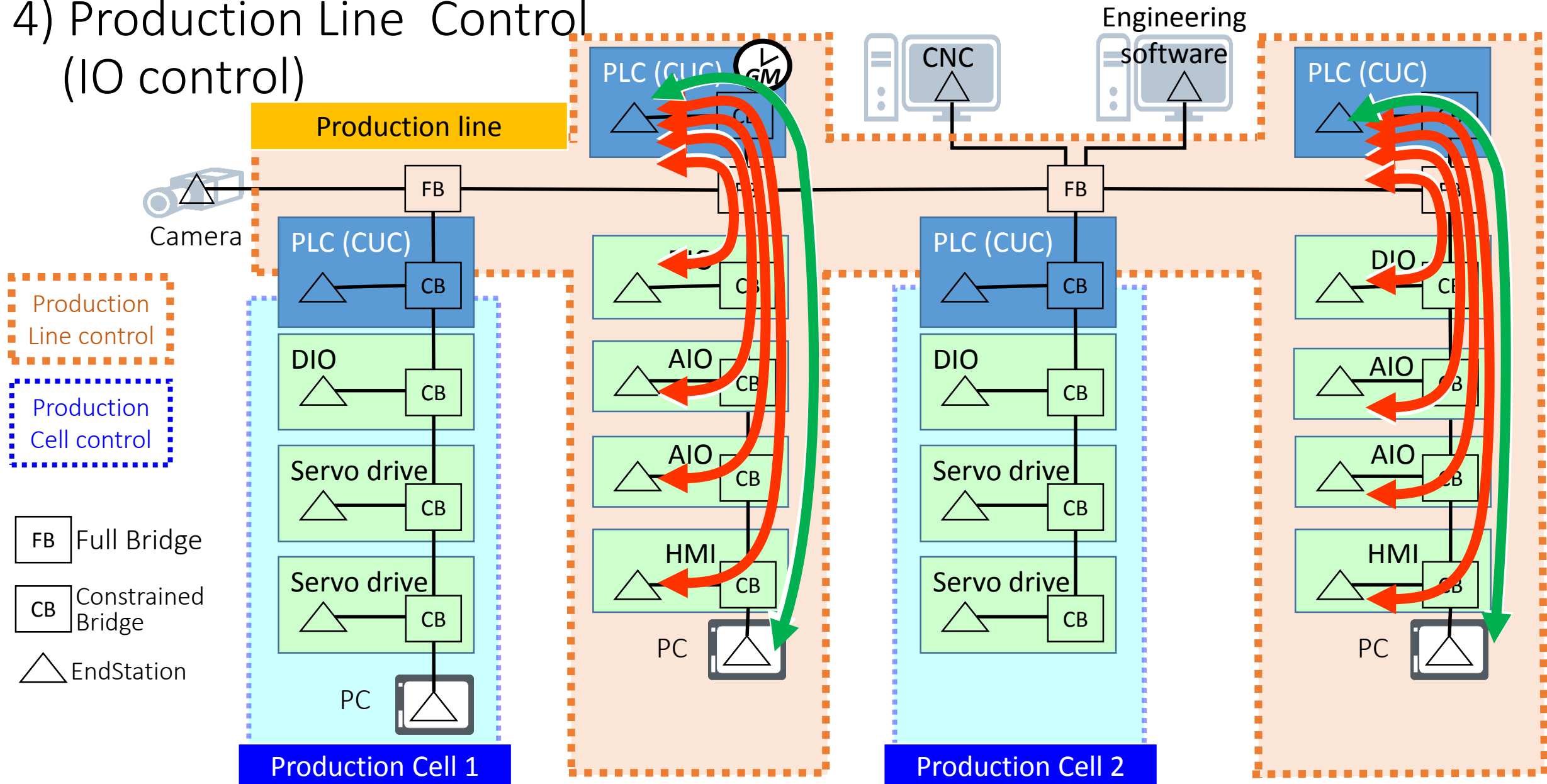
↔ (a) Time Sync
 (b) Cyclic
 (c) Config. & (d) Diag.
↔ (e) TCP/IP
 (f) UDP/IP

Streams in this system

4) Streams for **Production Line control (IO control)**

- (a) Periodic communication for Time synchronization
- (b) Cyclic communication for IO control
- (c) Sporadic communication for Config. between CUC in PLC and other devices
- (d) Sporadic communication for Diag. between PLC and other devices
- (e) Sporadic TCP/IP communication with PCs etc.

4) Production Line Control (IO control)

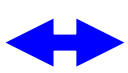
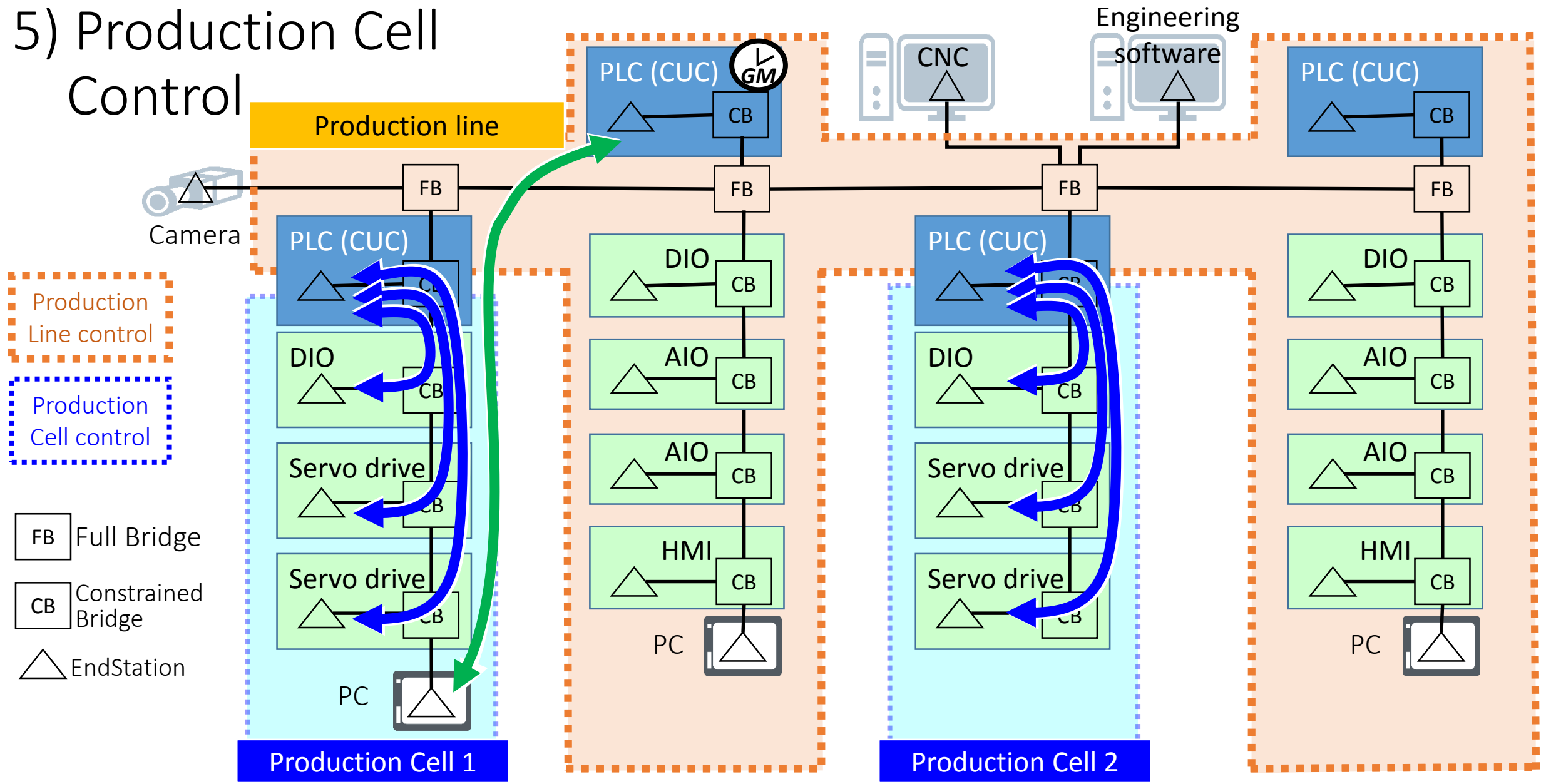


(a) Time Sync between PLC & device
 (b) Cyclic
 (c) Config. & (d) Diag.
 (e) TCP/IP

Streams in this system

- 5) Streams for **Production Cell control (Motion control)**
 - (a) Periodic communication for Time synchronization
 - (b) Isochronous communication for Motion control
 - (c) Sporadic communication for Config. between CUC in PLC and other devices
 - (d) Sporadic communication for Diag. between PLC and other devices
 - (e) Sporadic TCP/IP communication with PC etc.

5) Production Cell Control



(a) Time Sync between PLC & device
 (b) Isochronous
 (c) Config. & (d) Diag.



(e) TCP/IP

Stream characteristics in this system

No.	Types	Periodicity	Typical period	Synchronized to network	Data delivery guarantee	Tolerance to interference	Tolerance to loss	Typical application data size	Criticality
1	Isochronous	Periodic	31.25us - 2ms	Yes	Deadline	0	None	Fixed: 74-114 octet	High
2	Cyclic	Periodic	500us - 100 ms	No	Latency	<= latency	1 - 4 Frames	Fixed: 74 - 1500 octet	High
3	Events	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4	Network Control	Periodic	16ms - 1 s	No	Bandwidth	Yes	Yes	Variable: 46 - 1500 octet	High
5	Config.& Diagnostics	Sporadic	N/A	No	Bandwidth	N/A	Yes	Variable: 46 - 1500 octet	Medium
6	Best Effort	Sporadic	N/A	No	None	N/A	Yes	Variable: 46 - 1500 octet	Low
7	Video	Periodic	~33ms	No	Latency	N/A	Yes	Variable: 1000 - 1500 octet	Low
8	Audio/Voice	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Event information are mapped to isochronous and cyclic streams so we don't have Events traffic type in the table 21

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Needed traffic types in this system

No.	Traffic Types	Streams in this use case																		
		1) PLC Config. & Diag.	2) FB/CUC Config. & Diag.		3) Production Line control (Controller- Controller)						4) Production Line control (IO control)					5) Production Cell control (Motion control)				
			(a)	(b)	(a)	(b)	(c)	(d)	(e)	(f)	(a)	(b)	(c)	(d)	(e)	(a)	(b)	(c)	(d)	(e)
1	Isochronous																x			
2	Cyclic					x														
3	Events																			
4	Network Control					x														
5	Config.& Diagnostics	x	x	x			x	x											x	x
6	Best Effort									x										
7	Video																			
8	Audio/Voice																			

Needed traffic types

Needed traffic class in this system

No.	Traffic Types	Traffic Class	Streams in this use case				
			1) PLC Config. & Diag.	2) FB/CUC Config. & Diag.	3) Production Line control (Controller-Controller)	4) Production Line control (IO control)	5) Production Cell control (Motion control)
1	Isochronous	TC4					X
2	Cyclic	TC3			X	X	
3	Events	-					
4	Network Control	TC1			X	X	X
5	Config.& Diagnostics	TC0	X	X	X	X	X
6	Best Effort				X	X	X
7	Video	TC2			X		
8	Audio/Voice	-					

- Priority of TC: [High] TC4 > TC3 > TC2 > TC1 > TC0 [Low]
- TC7 to TC5 are not used.

Needed Traffic Types & Classes

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Queue set-up

- Min. 4 Traffic Classes are needed.

- Streams for PLC Config. & Diag. need only TC0.
- Streams for FB/CUC Config. & Diag. need only TC0.
- Streams for Production Cell control need TC4, TC1 & TC0
- Streams for Production Line control need TC3, TC1 & TC0

TC4: Isochronous, TC3: Cyclic, TC1: TimeSync, TC0: Best effort

* Video camera is connected to full bridge so constrained device does not care about it

Queue set-up

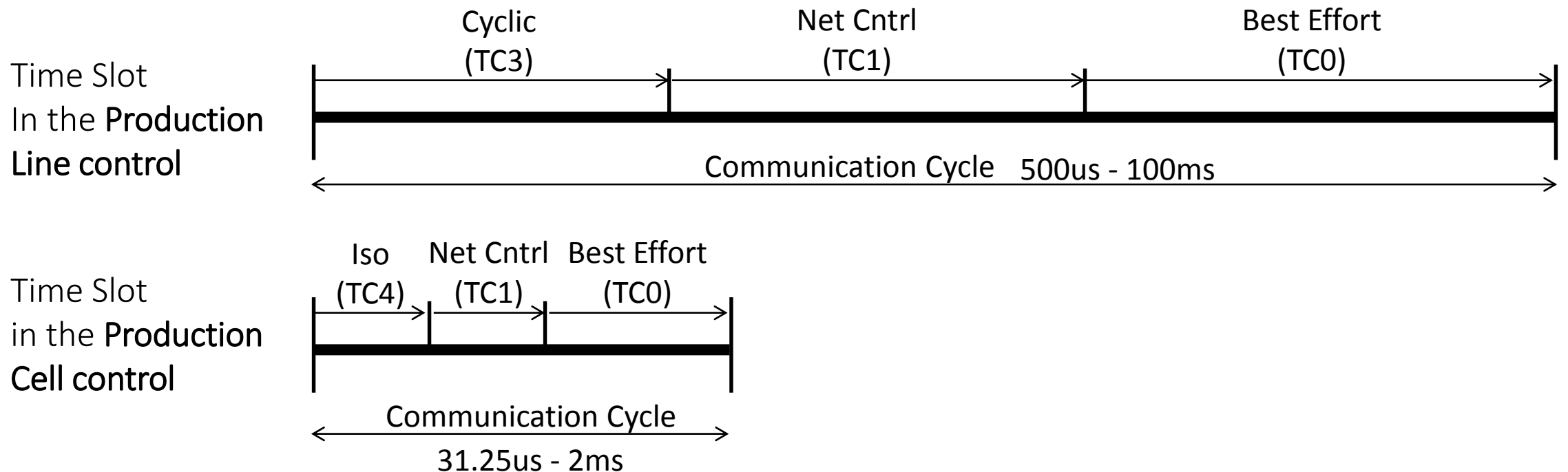
- CB which connects with both Production Cell and Line control covers all Traffic Classes

Queue setup example)

Queue ID	Traffic Class for Production Cell control	Traffic Class for Production Line control	Traffic Class for both of Production Cell & Line control	Minimum Buffer size	Scheduling
7-4	Not used	Not used	Not used	N/A	TAS
3	TC4	N/A	TC4	64 octet	
2	N/A	TC3	TC3	64 octet	
1	TC1	TC1	TC1	2048 octet	
0	TC0	TC0	TC0	2048 octet	

Qbv transmission selection timing set-up

- This system synchronizes bridges by 802.1AS
- The production line control and the cell control can have different time slot set-up.



Conclusions

- The shown system contains production cell control and production line control.
- The streams in this system are categorized as **six traffic types**.
- **Four queues** are sufficient to assign streams in **constrained bridge**.
- This system demonstrates one instance of transmission selection based on 802.1Qbv.
- **Both 802.1Qbv and 802.1AS** are necessary and sufficient for constrained bridge to control the streams in the shown system.

Thank you very much for your attention.

Appendix) Full bridge Queue set-up example

- Max. 5 Traffic Classes are needed.
 - Streams for PLC Config. & Diag. need only TC0.
 - Streams for FB/CUC Config. & Diag. need only TC0.
 - Streams for Production Cell control need TC4, TC1 & TC0
 - Streams for Production Line control need TC3, TC1 & TC0
 - Stream for video need only TC2

Appendix) Full bridge Queue set-up example

- FB covers all Traffic Classes.

Queue setup example)

Queue ID	Traffic Class for Line control	Minimum Buffer size	Scheduling
7-5	Not used	N/A	TAS
4	TC4	64 octet	
3	TC3	64 octet	
2	TC2	2048 octet	
1	TC1	2048 octet	
0	TC0	2048 octet	