NIDays

ENGINEER NEXT

Machine control with LabVIEW

MEquadrat AG

Member of the management, LabVIEW CLA

Felix Aeschimann

Agenda

- Company introduction
- Challenge
- The “machine”
- Safety
- Code
- Summary
- Outlook
- Questions

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Company Introduction

- Specialized in mechatronics
- Automated test systems
- Founded 2012
- National instruments alliance partner since 2012

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What makes us special

- We don’t do just the brainwork, we build the hardware, too

NATIONAL INSTRUMENTS Alliance Partner

maxon motor
driven by precision

CERTIFIED PREMIUM PARTNER 2017 KOLLMORGEN

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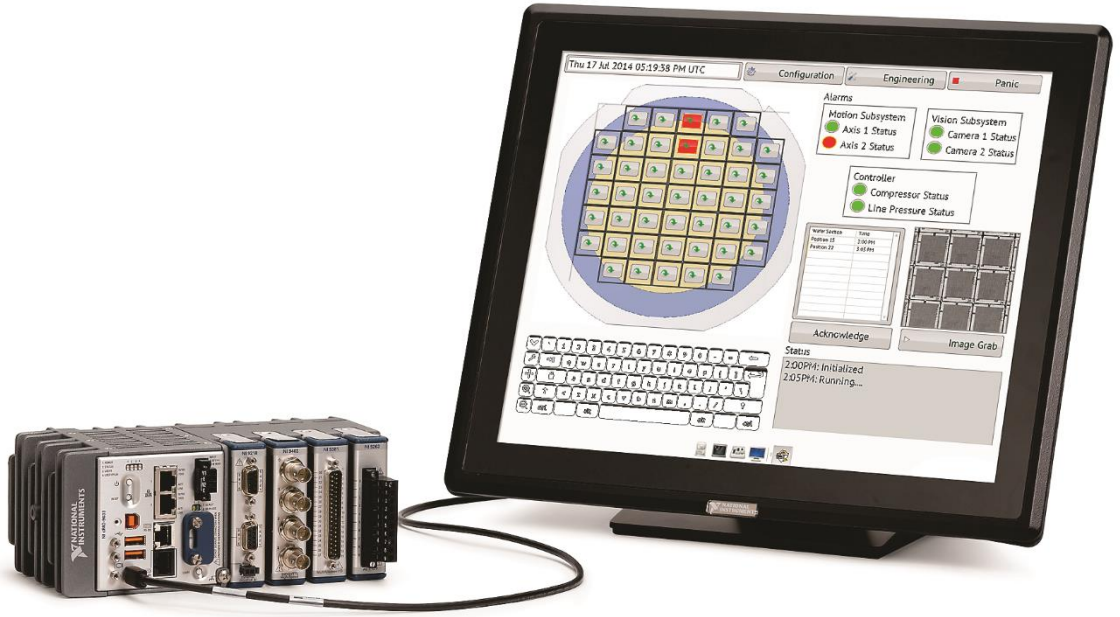
Challenge

Why we love LabVIEW for testing

- Wide range of dedicated modules
- Precise measurements at a high data rate
- Simple hardware configuration
- Built for data handling



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So why not use this in a production machine?

Measurement
(cRIO / PXI)

Process Control
(PLC)

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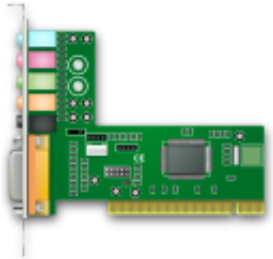
Simple machine

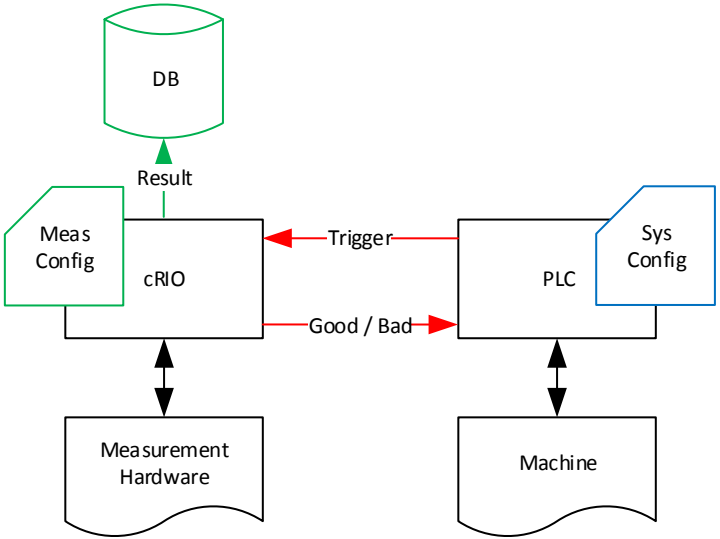
- One type of DUT



- Digitial IO interface
  - PLC triggers cRIO
  - cRIO sends good/bad information

- cRIO: measurement configuration
  - cRIO is configured for this article
  - cRIO logs result directly

- PLC: machine configuration
  - DUT handling



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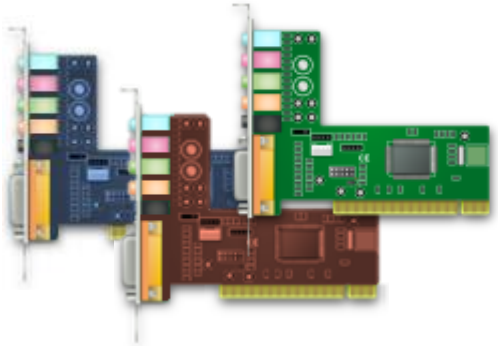
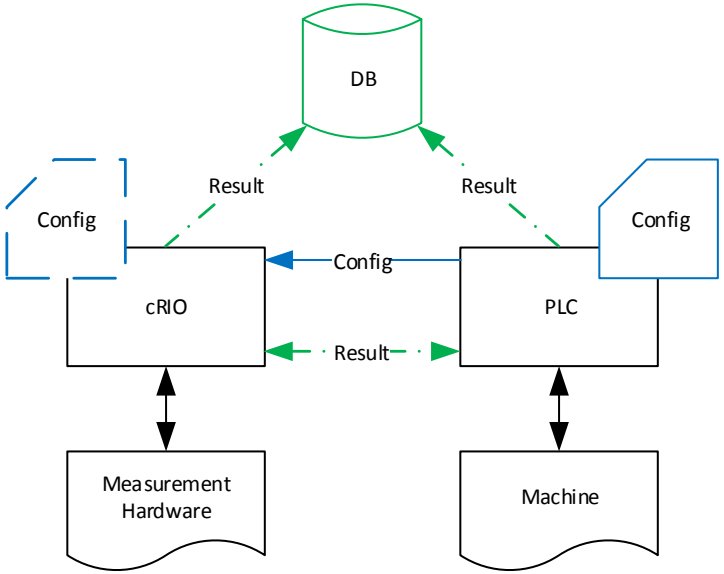
More complicated machine

- Different DUT processed on the same machine
- Digital IO no longer sufficient
  - Both sides need to know the article
  - Urge to avoid splitting the settings
- …and who logs?
  - cRIO has measurement results
  - PLC may want to add own data
  - Who's the master of the DB?



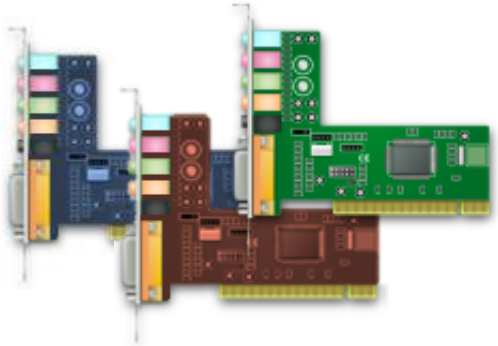


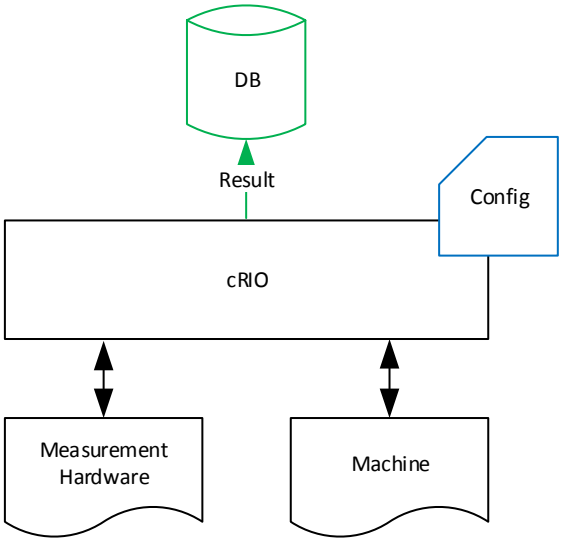
Why not get rid of the interface?

- «Eine Schnittstelle ist eine Schnitt-Stelle»
  - German way to say interfaces are tricky

- Pros
  - Lower system complexity
  - Simple configuration handling
  - Simple result handling

- Cons
  - Now there's a «Machine» block next to our cRIO…?





The «machine»


KOLMORGEN
AKD
EtherCAT
OPEN
CLOSE
STOP
ON
OFF
STOP
PI E-871 PIShift Controller
RS-232 In
RS-232 Out
STA
ERR
I/O
Joystick
Mode
Baud
Addr
EPOS3
Hall Sensor
Encoder
USB
IN
OUT
Signal 1
Signal 2
Signal 3
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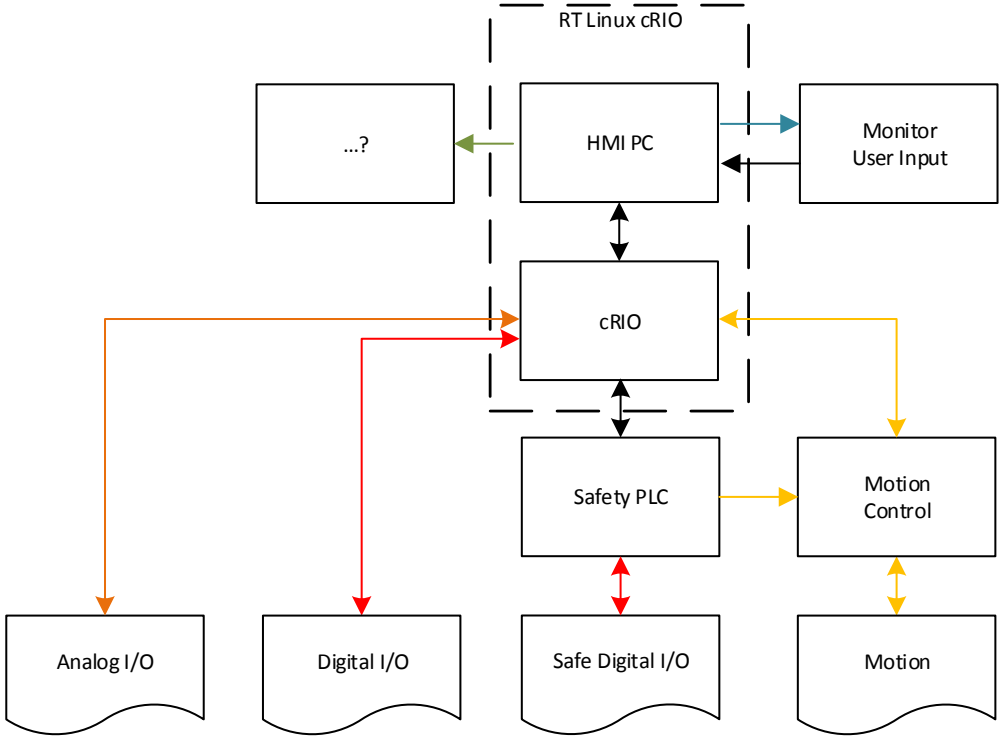
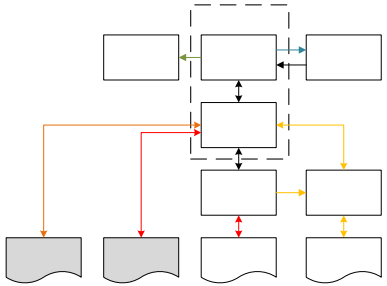
What’s behind the «machine»?



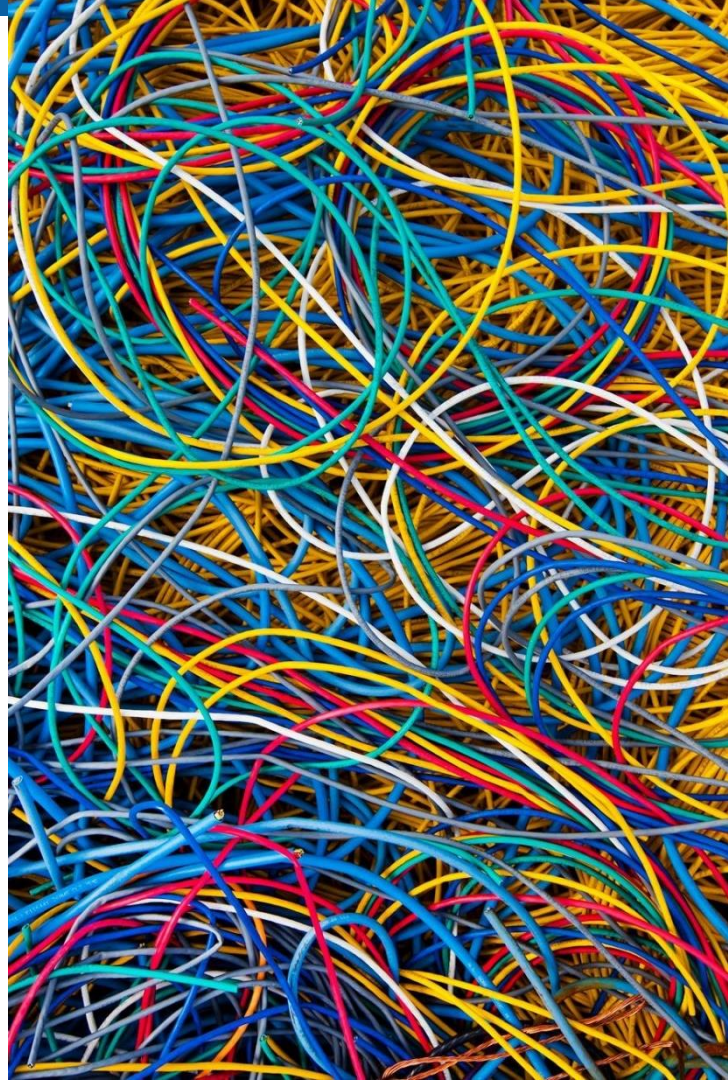
Analog and digital IO

- C Series modules
  - FPGA if time is a matter
- Expansion Chassis
  - C Series modules
  - FPGA available, too
- Third-Party remote IO Systems
  - Bus based systems with some limitations



Follow industrial standards

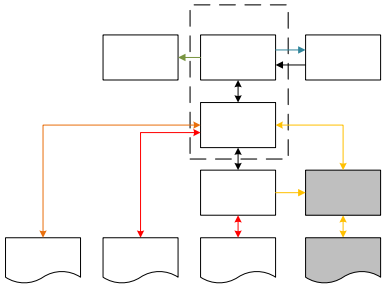
- Digital IO levels
  - 24VDC
- Analog IO levels
  - Voltage types: +/- 10V
  - Current types: 0..20mA / 4..20mA
- Checklist
  - Don’t use the cRIO to distribute supply
  - Use properly labelled clamps
  - Don’t forget the fuses
  - Use shielding and short routing on analog wires



Motion control

- SoftMotion
  - Kollmorgen AKD
  - MAXON MAXPOS
  - …some others

- Third-party devices
  - PI piezo stage controller
  - MAXON EPOS
  - Jenny Science XENAX
  - FESTO valve cluster
  - …many others



EtherCAT

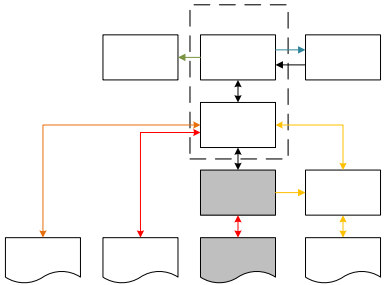
- Advantages
  - Many devices available off the shelf
  - Fast and reliable

- Traps
  - Let’s be honest – there’s EtherCAT…
    …and than there’s NI-EtherCAT
  - Kollmorgen AKD-C/N
  - Any device that sends arrays such as remote IO systems

Alternatives to EtherCAT

- Ethernet TCP/IP
- Modbus TCP
  - Fast and stable
  - Does not block an additional RJ45-Port
- Serial
  - Old but gold
  - Easy to implement
- Digital / Analog IO
  - If theres no data to be sent – keep it simple

Safety



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Safety considerations

- Which parts need safety?
  - Risk assessment for the whole machine
  - See «Maschinenrichtlinie 2014/42/EG»
- In general
  - Everything that moves is evil (motors, cylinders, …)
  - Everything that may hurt is evil (lasers, knifes, …)
  - If it’s invisible, ist even more evil (lasers, …)
- Safety systems shall mitigate these risks
  - Detecting user intrusion
  - Locking the user out

What shall the safety tell you?

- Nothing?
  - Handle by reading STO state from motion controller
- Overall state?
  - «Safety circuit not operational»
  - → Simple IO's sufficient
- Full detail?
  - «Left door not closed»
  - → Many IO's
  - → Consider using a bus

What do you tell the safety?

- Nothing?
  - Isolated system just doing his job
- Superior commands?
  - «Lock»
  - → Simple IO’s sufficient
- Detailed commands?
  - «Lock left door»
  - → Many IO’s
  - → Consider using a bus

Is it simple? - Safety relays!

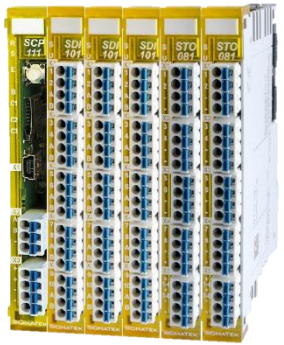
- Suitable when
  - Not many IO's to handle
  - No complex processes to follow
- System range
  - Base version have fixed built-in functionality
  - Advanced ones may be configured using a dedicated software
- Disadvantages
  - Not very extensible
  - May lead to additional wiring when reading the inputs, too

It isn’t that simple? – Safety PLC!

- Suitable when
  - Many IO’s to handle
  - Safety processes to follow

- Advantages
  - Configurable through dedicated software
  - Extensible for future enhancement

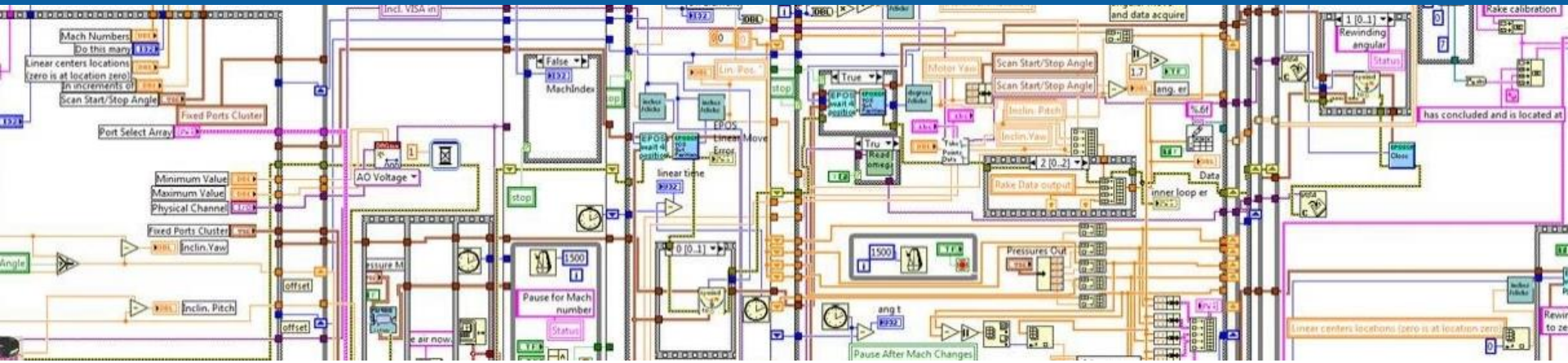
- Tips
  - Use digital IO’s if you only need the overall state
  - Use a simple bus if you need true interaction
  - Avoid types that require the master to handshake safety protocols



And what about direct integration?

- Currently not possible

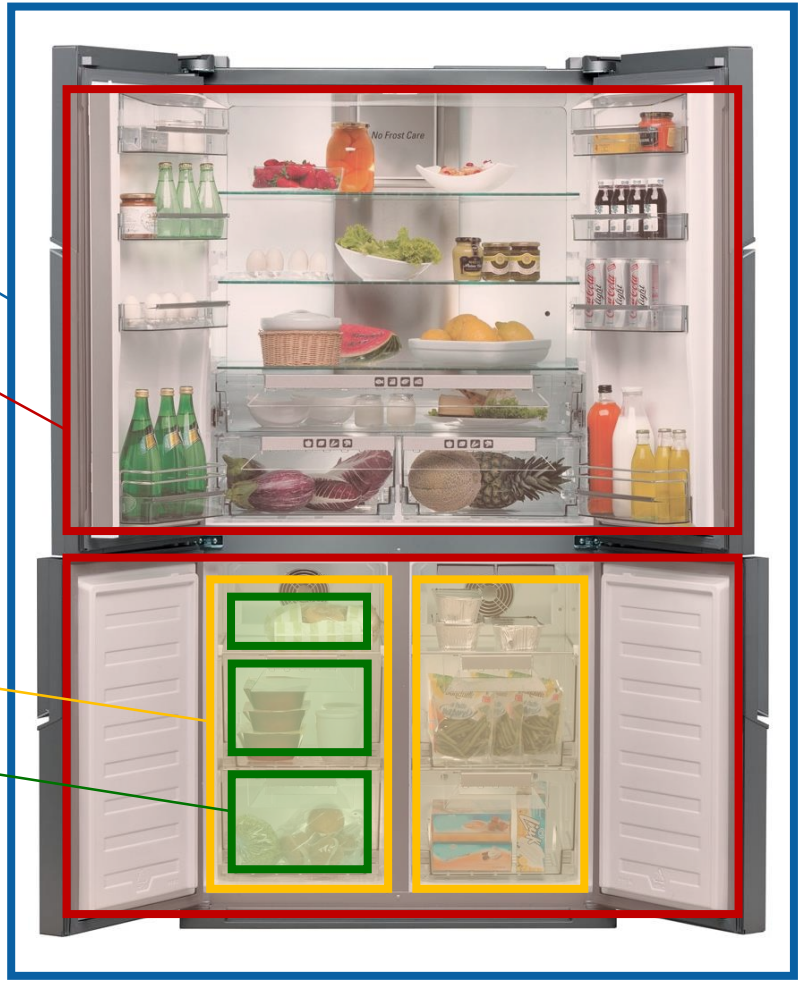
- Subject to change: http://www.ni.com/white-paper/53844/en/



Code

Disclaimer: Sorry, there's no actual code in these slides!

Structured naming



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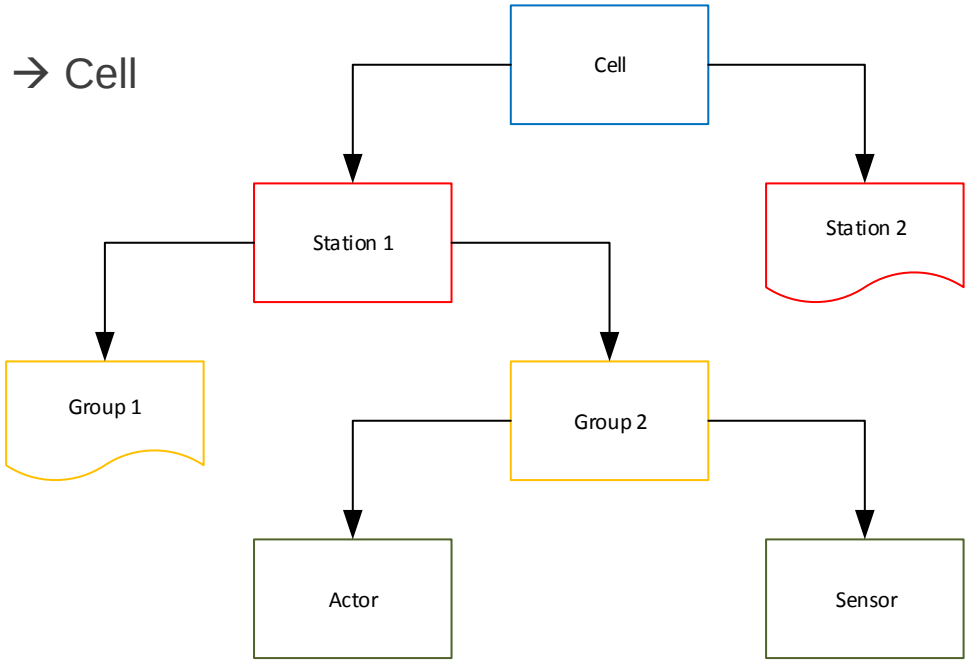
Design approach

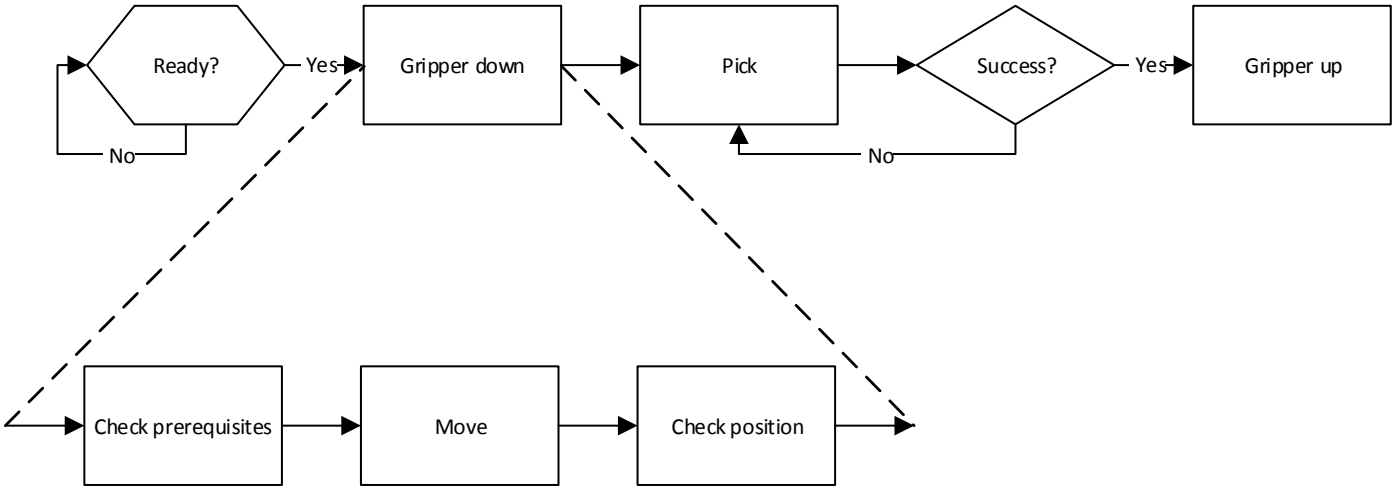
- Think top-down
  - Cell → Station → Group → Sensor / Actor

- Implement bottom-up
  - Sensor / Actor → Group → Station → Cell



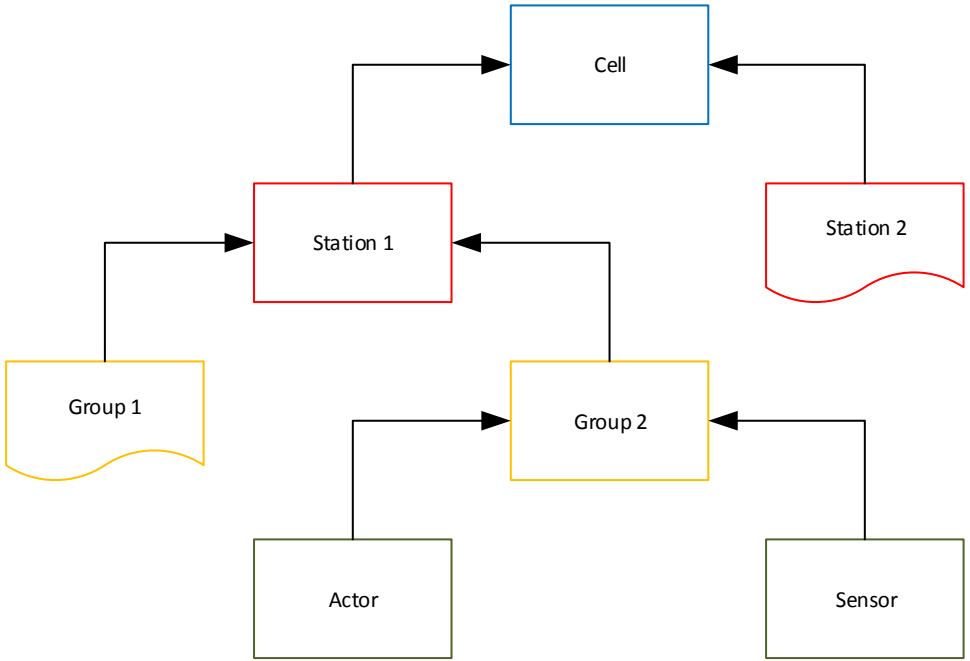
Don’t be stuck to a design pattern

- Some things are state machines
- Other things aren’t
- The cell certainly is



Divide responsibility

- The cell shouldn’t care if actor X is in position
- But the cell should care if station Y is ready



Some thougts on errorhandling

- Don’t stop on unimportant errors
  - A stop decreases the performance
  - Consider unattended running (overnight)

- Classify errors and handle them accordingly
  - Safety issue? → Stop the process immediately
  - Fault? → Try to finish the DUT / Cell cycle
  - Warning? → Try to finish the batch

- Avoid affecting neighbours
  - An error on station 1 should not affect station 2

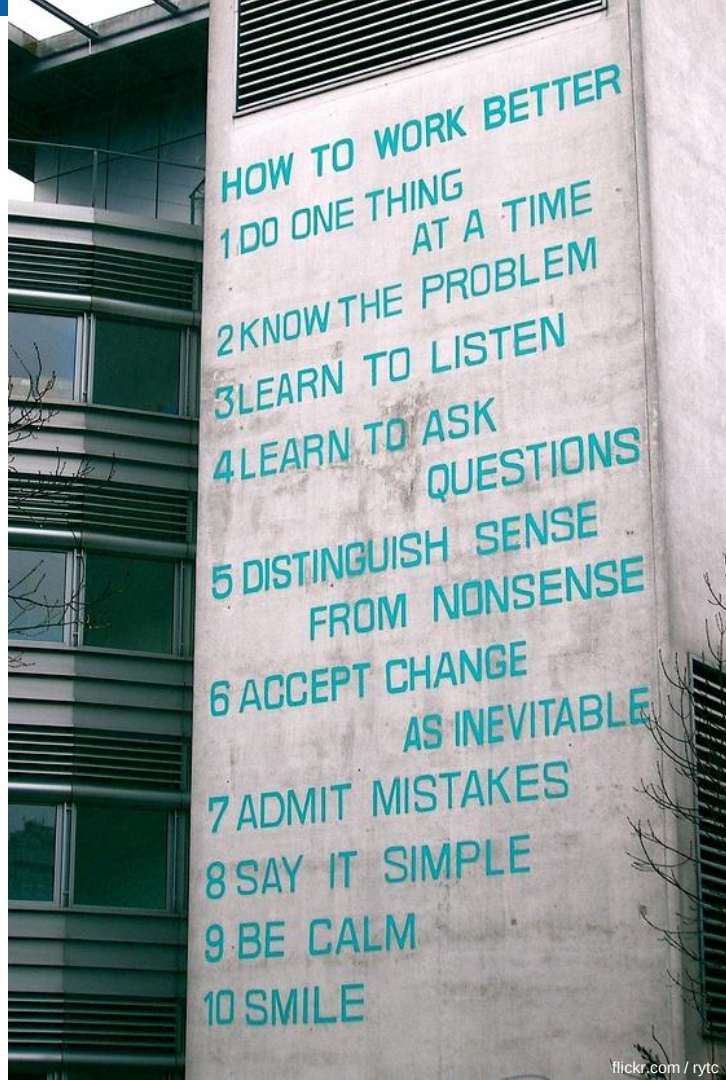
Always be prepared for an emergency stop!

- The user may interrupt your machine anytime
- Implement routines that are able to «clean up»
  - Machine state
  - Actor position
- Don’t mess up DUT position and DUT data
  - Actors may move when cleaning up

- Checklist
  - Bottom-up approach: Group → Station → Cell
  - Consider hardware for DUT identification

Accept change as inevitable

- Product changes may happen
  - Allow changing or adding of article parameters
- Machine changes may happen
  - Allow changing or adding of machine parameters
  - Step sequence may change
  - Actors may change
- Checklist
  - Don’t use constants
  - Don’t code anything twice
  - Don’t fix your sequence too much



Dont’s

- Don’t access hardware simultaneously
  - Use semaphores
  - Use scan engine
- Don’t poll
  - If indispensable, use delay and timeout
- Constants
  - Again, don’t do that.

Summary

Con’s

- Machine control tasks are not easy
  - Additional hardware to control
  - Additional interfaces to implement in LabVIEW
- Safety can not (yet) be directly integrated
  - Additional interface necessary for larger systems
- Not all toolkits are available on RT
  - Database Toolkit
  - Report generation toolkit

Pro’s

- One software to rule the whole machine
  - One parameter file for the whole machine
  - Less handshaking, interfacing, …
- Full control over the whole process
  - Route DUT depending on measurement outcome
  - Low latency on sensor / actor interaction
- Measurement capabilities of LabVIEW /NI-Hardware
  - High data rates and resolution
  - Vision integration possible
  - Advanced data handling capabilities

MEquadrat experiences

- Integrating machine control into LabVIEW needs experience
  - We had startup-troubles, too ☺
  - A stable base framework eases development

- Positive customer feedback
  - Reliable production machines
  - Outstanding measurement performance
  - Running in multi-shift operations

Single station production machine

- Mechanical engineering
  - Outer stick diameter 0.65mm
  - Taylormade rotational axes
  - Concentricity 2µm
- Hardware
  - NI cRIO 9638 running application and HMI
  - Safety Relays
- Motion
  - 4 Axis SoftMotion
  - EtherCAT-based gearing

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Six station rotary table machine

- Production with integrated testing

- Hardware
  - NI IC-3173 running application and HMI
  - NI EtherCAT expansion chassis
  - NI EtherNet expansion chassis / FPGA
  - FESTO EtherCAT valve cluster
  - Sigmatek Safety PLC

- Motion
  - 22 Axis using various protocols
    EtherCAT / EtherNet / RS232 / Modbus TCP

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Outlook

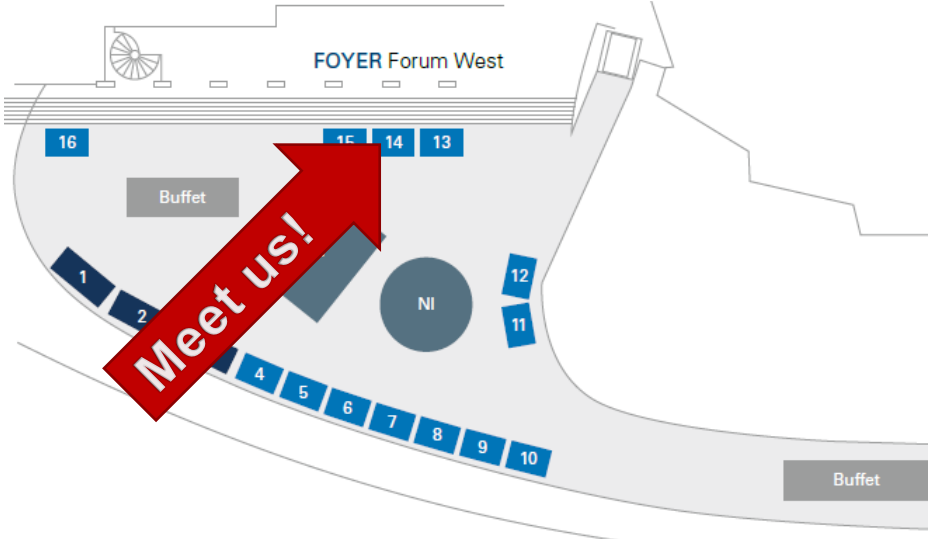
Outlook

- Switch the master
  - Let LabVIEW and NI-Hardware actuate the system
  - Let TestStand control the sequence and results

- Integrate safety logic
  - Less interfaces, less trouble (hopefully)

Questions?

- Or meet us at booth 14



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