



The logo for NIDays Engineer Next is centered on a blue background with diagonal stripes. It features the text "NIDays" in white inside a white rectangular box, followed by the words "ENGINEER" and "NEXT" in large, bold, white capital letters. A yellow graphic element, resembling a stylized 'N' or a folded ribbon, is positioned between "ENGINEER" and "NEXT".

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Real-World Tips for Synchronizing Distributed DAQ Systems

Stefano Stablum
National Instruments Italy - Application Engineer

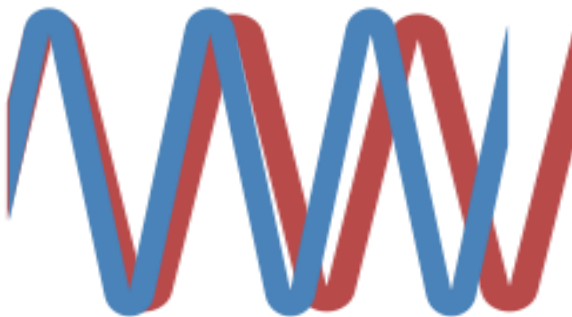
Agenda

- What is synchronization?
- What are the different types of synchronization?
- Different factors you should consider for your distributed application
- Selecting a topology for your distributed application
- Best practices when implementing your application

What is Synchronization?

- Data from multiple devices can be correlated with a known amount of uncertainty
- There are two requirements to be truly synchronized:
 - Start simultaneously
 - Do not drift over time
- Drift refers to differences in sampling frequency over time.

Small errors at
beginning of acquisition



Larger errors as
acquisition continues

What are the Different Types of Synchronization?

Signal-Based Synchronization

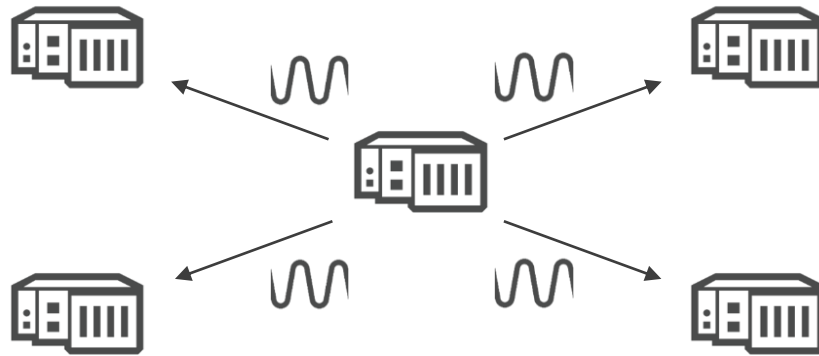
- Timing signals are shared directly connected with cables



Time-Based Synchronization

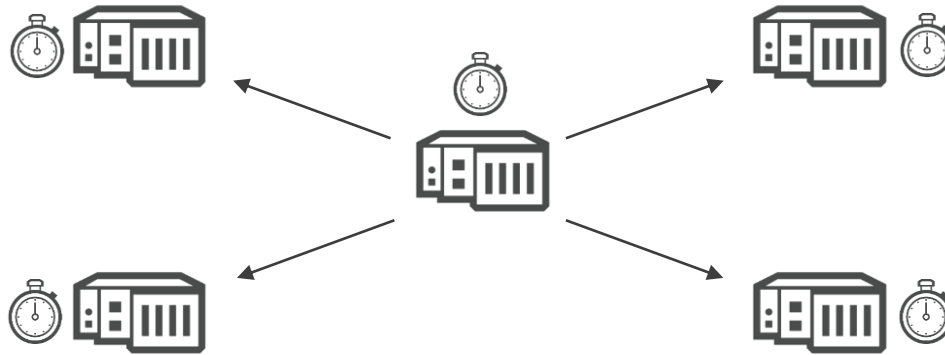
- Timing signals are derived from a common time reference





Signal-Based Synchronization

- The master device exports timing signals to slave devices
- All of the systems acquire together, but the slave chassis are unaware of the the time the data was taken



Time-Based Synchronization

- Each node locks its local time to a global system time
- All of the systems acquire together and the slave chassis are aware of the time the data was taken

Signal-Based Versus Time-Based Synchronization

Signal-Based Synchronization

- Tightest synchronization
- Requires specific cabling and/or breakout hardware
- Application implementation varies by product
- Slaves do not have a notion of time

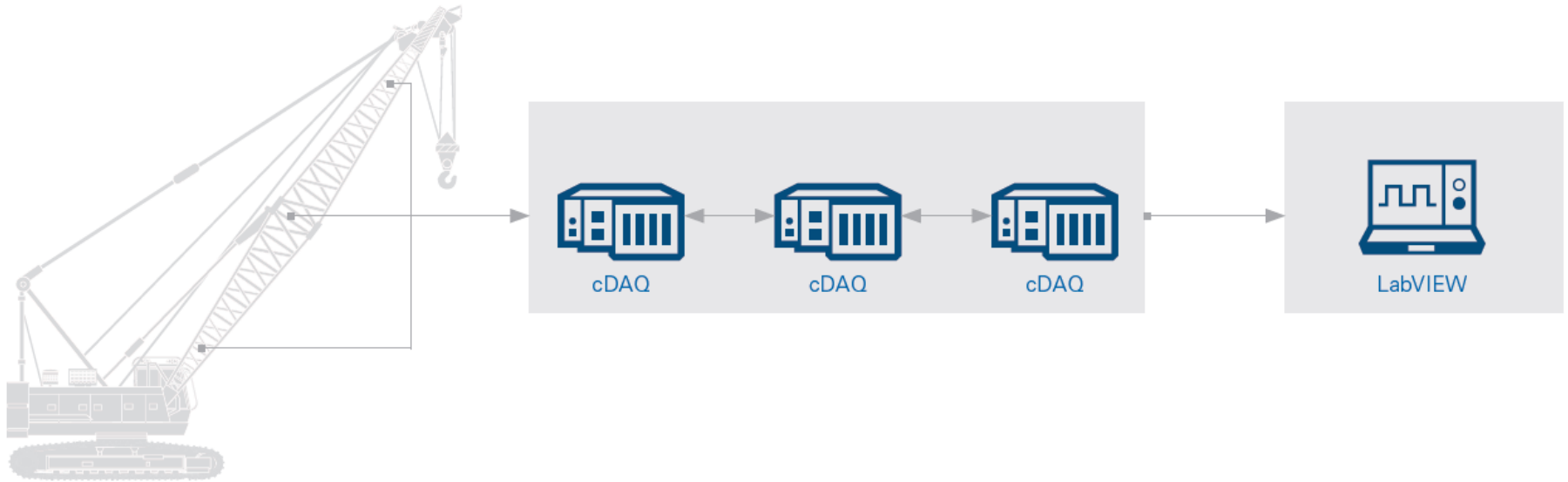


Time-Based Synchronization

- Accurate synchronization over network with standard cables and hardware
- Application implementation is not product-specific
- Slaves have a notion of time



Which Synchronization Type Would Be Preferred?



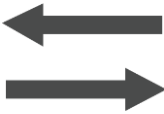
Other Factors to Consider when Designing your System



- System Flexibility



- Scale of System



- System Bandwidth



- System Reliability



Flexibility of the System/Application



- Do you need to be able to add or remove channels from the system easily?
- Ability to use this HW for different types of tests (extensibility and re-use)



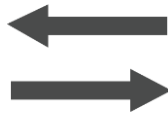
How Large of a Geographical Area?



- How far apart are your chassis?
- How large is the DUT?
- How close to the DUT do you need to be?



Total Bandwidth of the System



- Number of channels and sample rates for individual devices
- Total throughput requirements for network infrastructure and host PCs or embedded controllers



How Reliable do you Need your System to be?



- Do you need to be able to handle network infrastructure of cabling failures?
- Must the system remain operational even if a single chassis is interrupted?
- Do you need to be able to set safe-states for your output in the case of loss of connectivity?

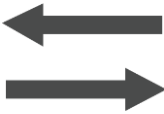
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- System Reliability

The Evolution of Ethernet Time Sensitive Networking

Convergence

Provides standardized management tools which can 'see' everything on an Ethernet network

Synchronization

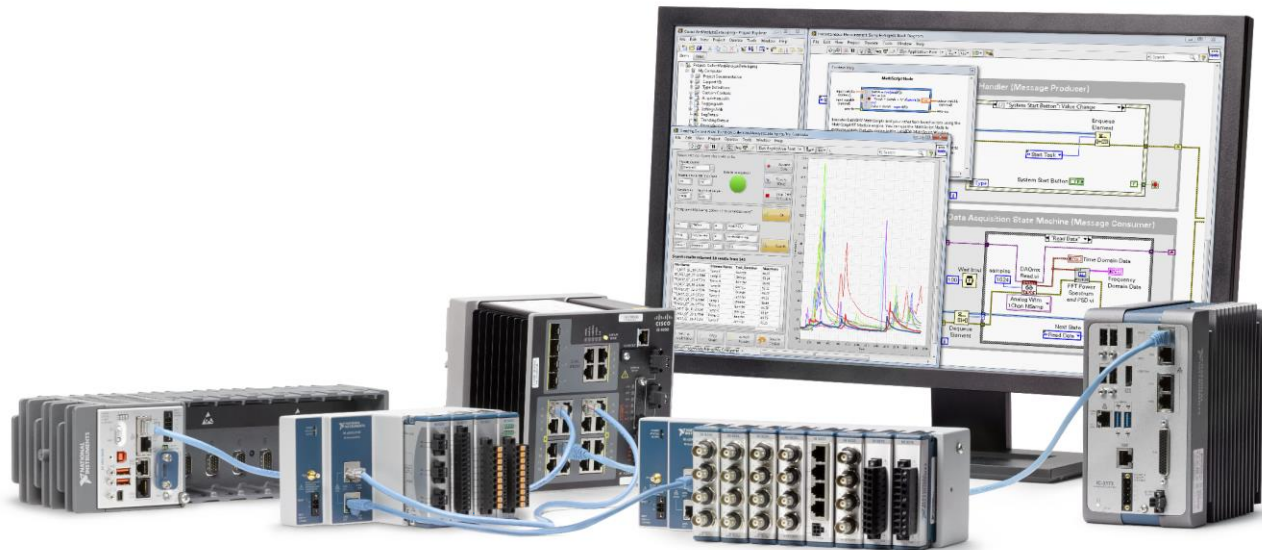
Correlated analytics across subsystems and distributed networks

Interoperability

Choose best in class equipment for your application

NI's Approach

Take advantage of NI leadership in standard's bodies and 30 years of investment in industry technology



CompactDAQ with TSN

Scale Effortlessly

Precise timing and synchronization regardless of system size with TSN

Deploy Anywhere

-40 to 70° C Temp Range
50g shock, 5g vibration
Hazardous locations certifications

Streamline Configuration

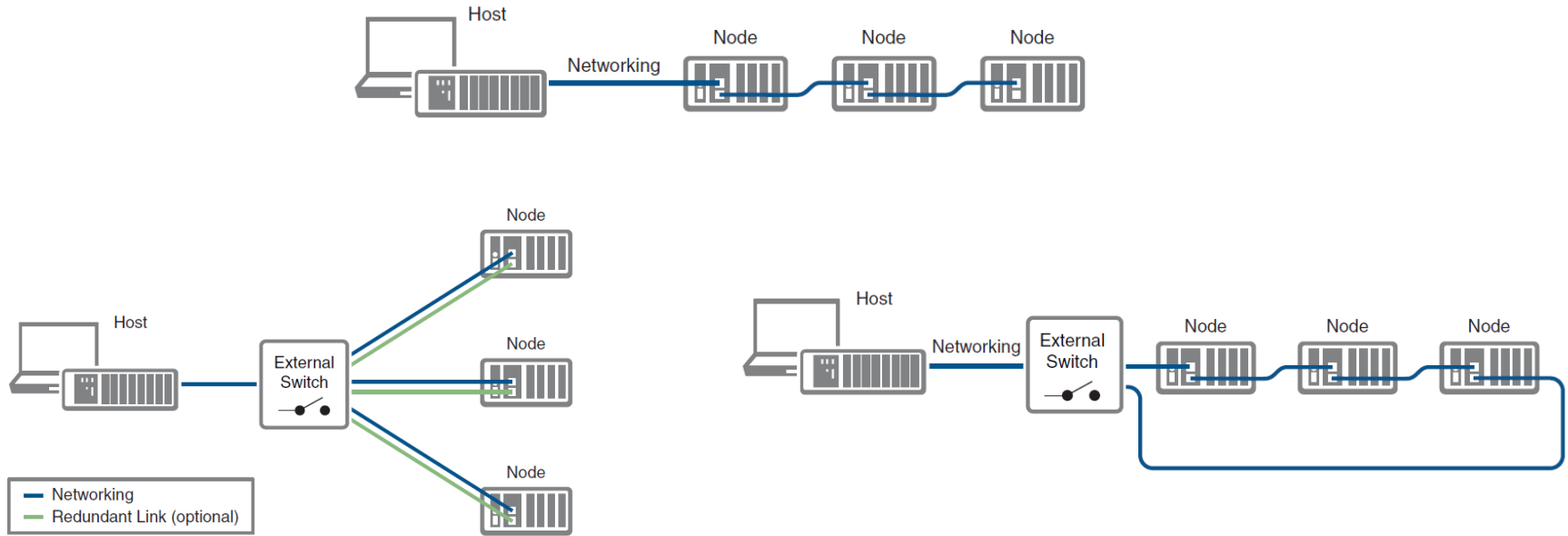
Integrated switch simplifies setup and wiring with simple daisy chaining



Meet Your Exact Needs

Wide Breadth of Modular I/O for frequently changing requirements

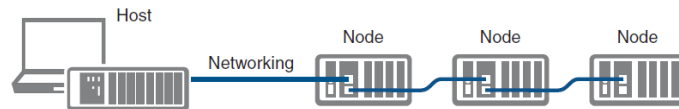
Selecting a Topology for Your Application



Selecting a Topology for Your Application

Line Topology

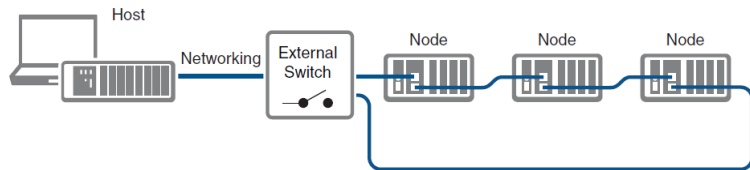
- Pros:
 - Simple and inexpensive installation, expansion, and troubleshooting
 - No external hardware needed
 - Ideal for low number of nodes
- Cons:
 - Any unpowered node and/or node failure disrupts network communication
 - Failure of any Ethernet cable and/or improper cable termination disrupts network communication
 - Addition or removal of any node can disrupt network communication



Selecting a Topology for Your Application

Ring Topology

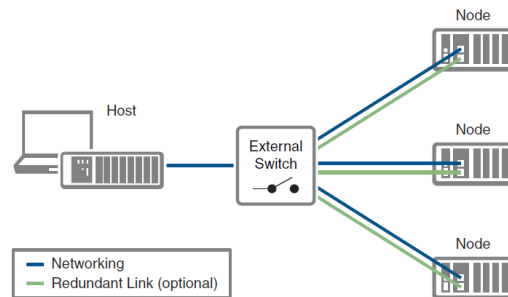
- Pros:
 - Simple and inexpensive installation and expansion
 - Failure of any single Ethernet cable does not disrupt network communication
 - Ideal for a local networking solution
- Cons:
 - Network traffic patterns can make troubleshooting difficult
 - Requires an external switch



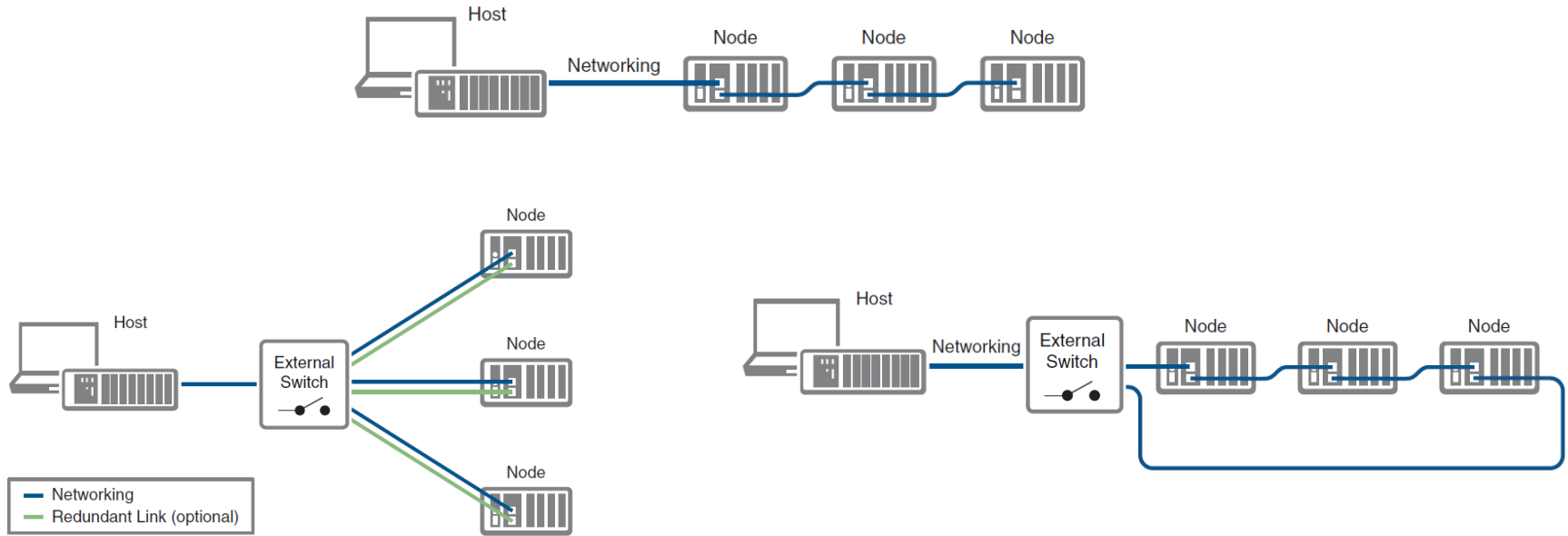
Selecting a Topology for Your Application

Star Topology

- Pros:
 - Unpowered nodes and/or node failure does not disrupt network communication with other nodes
 - Additional nodes or heavier network traffic affects network performance less than the other topologies
 - Simple installation, expansion, and troubleshooting
- Cons:
 - Most costly of the recommended topologies
 - Requires an external switch
 - Covers the least distance



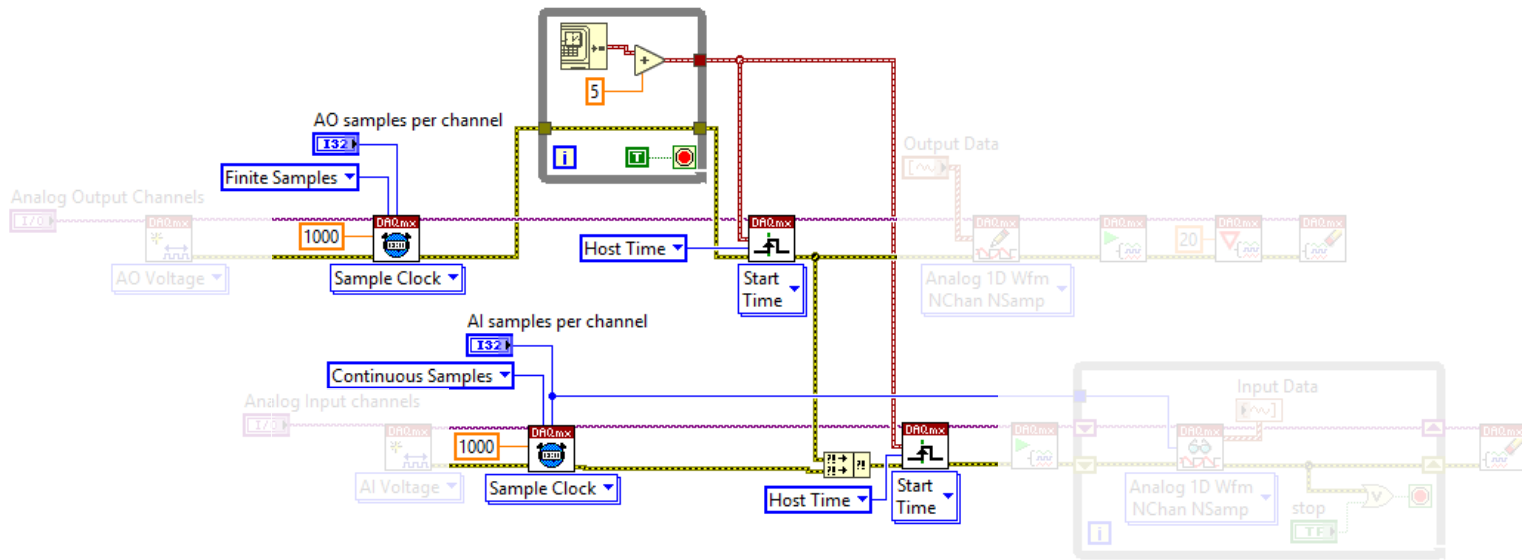
Selecting a Topology for Your Application





Tips and Best Practices when Developing Distributed DAQ Applications

- Application development for simplicity
- More advanced application development
- Reliability and fail-safe mechanisms for the application



More Advanced Development Techniques

- Individual tasks for different measurement types
 - Gives the ability to synchronize different types of measurements in the system (such as AI and AO) with a single time trigger

In Conclusion

- There are a lot of factors to consider when designing and implementing a synchronized distributed DAQ system
- All solutions come with pros and cons
- Most applications are best served with time-based synchronization over TSN Ethernet



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