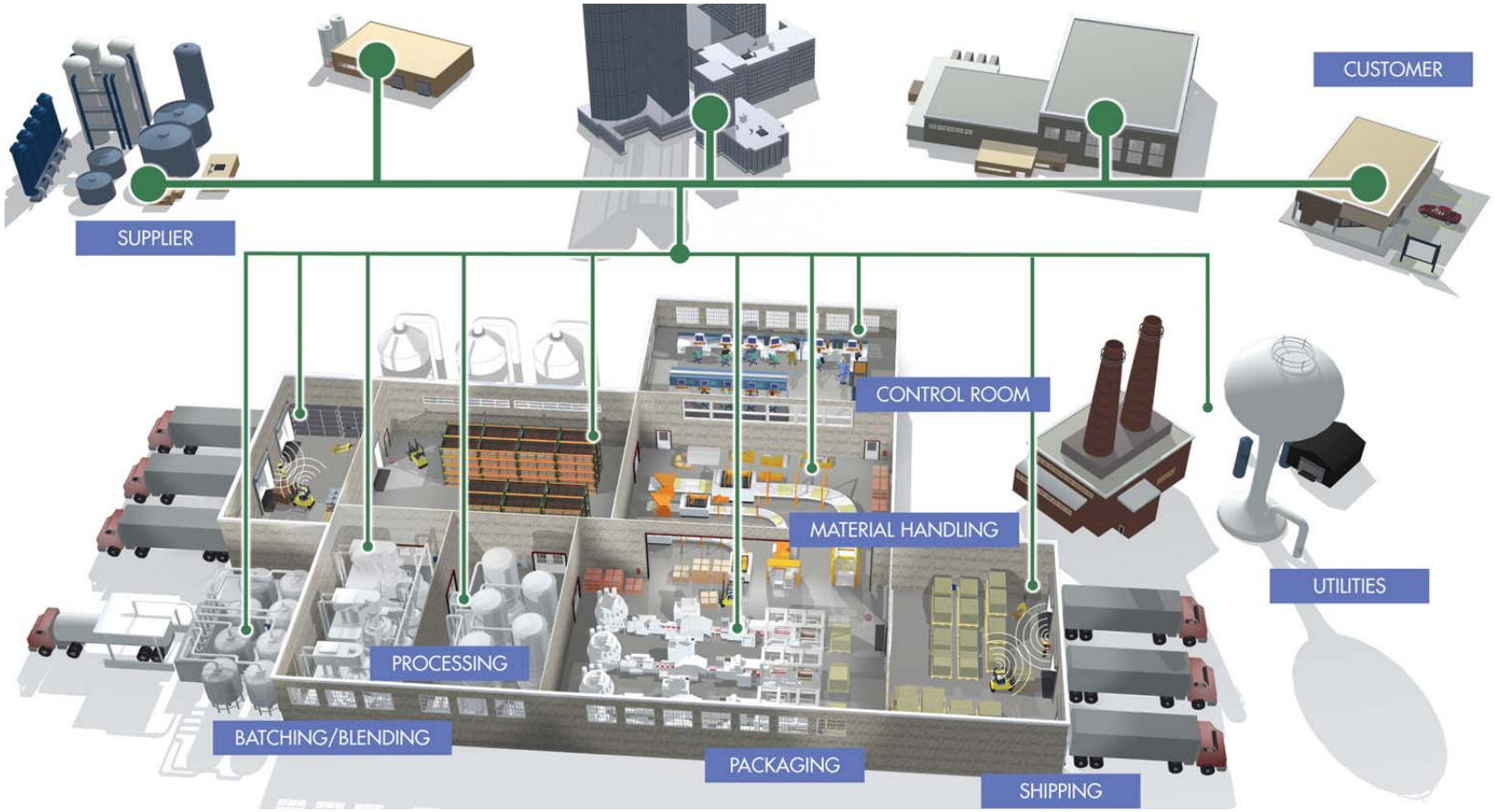
E-Manufacturing, the Web, and Things Talking To Things



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Objectives

- Give us Database and Transaction processing folks a peek at an "alternate computing universe"

- Take a look at how changes on the factory floor are going to impact our systems over time

Factories are Changing Radically

- Traditionally (10 years ago), the factory "controls guys" talked to the PLC/DAQ controls vendors and made the key factory automation decisions, and the DP managers just listened in.

- Today, those roles have almost completely reversed. The DP managers are now making key factory automation decisions, and the "controls guys" are left listening in.

- The primary mover for this change is "E-Manufacturing"

What Is E-Manufacturing

- Application of Internet and E-business technologies to the manufacturing environment

- Integration of a company's manufacturing activities into a complete process flow system:
  - » Design and Development
  - » Supply-chain
  - » Inventory - Stock-On-Hand (SOH), Work In Progress (WIP), **...**
  - » Factory Floor - scheduling of work and machines
    - routing of parts and supplies

- Key Drivers
  - » Web-based Supply-Chain integration allows better control of inventories and enables "build-to-order"
  - » Customer demands for mass customization
  - » Explosion of intelligence out on the factory floor

Why do we care

- Our databases and will transaction systems will have to accommodate the additional needs that these intelligent factory and sensor-based systems require:
  - » Sensors often need to be paired with calibration values, which are then used to process incoming Raw data into calibrated form
  - » Sensor data often needs to be aggregated and used in time series type of analysis
  - » Output data to factory is often a series of values (not just a single number) in order to drive analog outputs
  - » Data often needs to be converted into graphical form, including trending and correlation (HMI)

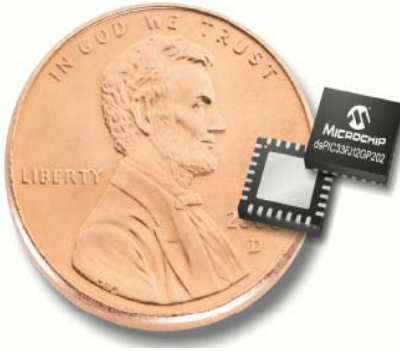
- In manufacturing industries, over time, Machine-to-Machine communication will dominate all other traffic. It will also be a primary driver (and receiver) of DBMS/TXP interactions
  - » Supply-chain: convert data from customized orders into control data sent to machines on factory floor
  - » Corporate critical data needed for legal reporting/auditing of factory processes forwarded to corporate databases

Key Driver: Mass Customization

- Use of flexible computer-aided manufacturing systems to produce custom output:
  - » Combine low unit costs of mass production processes with the flexibility of individual customization.
  - » Allow customer interaction at the fabrication / assembly stages of the manufacturing processes to create customized products at prices similar to mass-produced products.
- Keys to achieving this:
  - » Must have absolute control over costs and inventories
    ==> more data and more timely reporting and analysis of that data
  - » Must be able to re-configure easily and at low cost
    ==> automate the corporate-level order system with manufacturing line
- Examples
  - » Dell Computer
  - » Boeing (new 787 airliner)

Key Driver: Explosion of Intelligence in Factory

- High horsepower, small size micro-controllers are changing the way data collection works. Are being embedded right down into the factory sensors and actuators. And they all communicate !
- Result is that "digital" intelligence is being pushed further down and further up in the factory - "things talking to things"
- Net-net will be more transactions and data flowing directly from the commercial side to/from the factory side to support:
  - » Mass customization
  - » Supply-chain response
  - » Legal requirements (tracking of temp, stg time, … for pharmaceuticals, dairies, food processing, …) - non-compliance WILL SHUT YOU DOWN



dsPIC33FJ12GP 16-bit microcontroller has as much horsepower as a VAX (40MIPs) but is 1/8 the size of a penny

What's Involved in E-Manufacturing

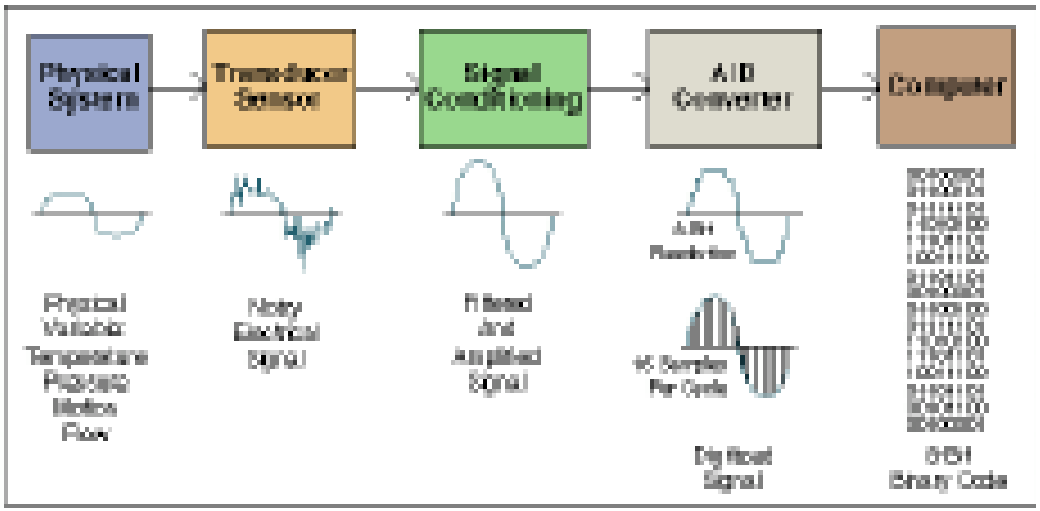
- Analog/Digital Conversion, Sensors, Actuators
- PLCs
- DAQs
- SCADA
- Ladder Logic Programming

The World is Analog

- Computer people are digital

  but the "real world" is analog.

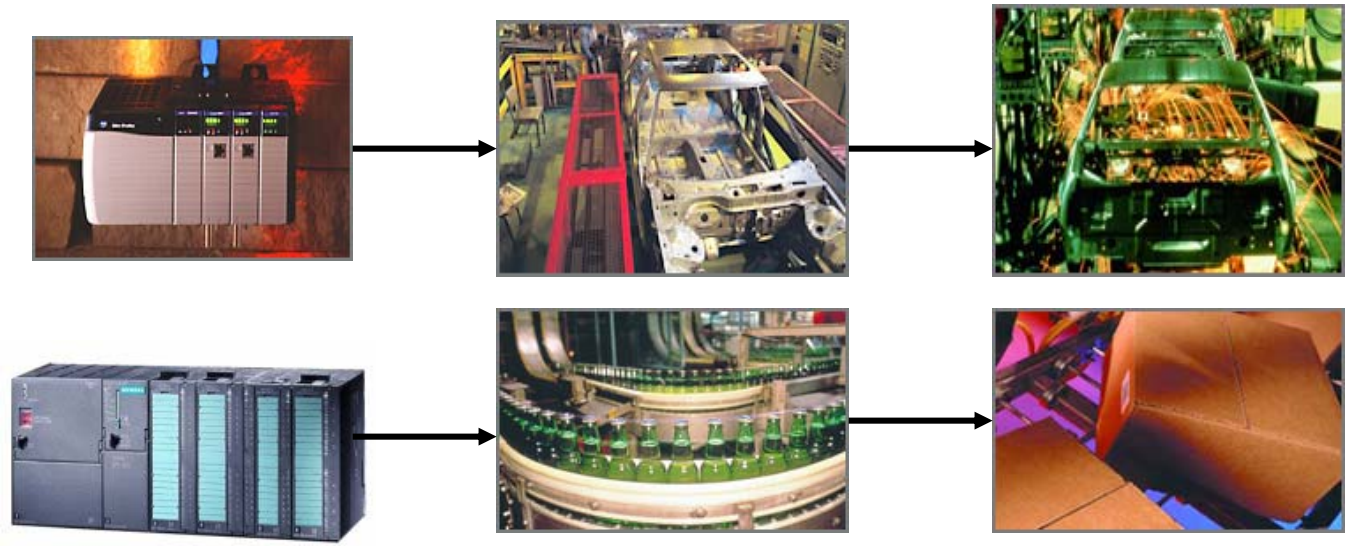
- On input, analog data is sampled and converted to digital - ADC
  On output, digital data is converted back to analog - DAC



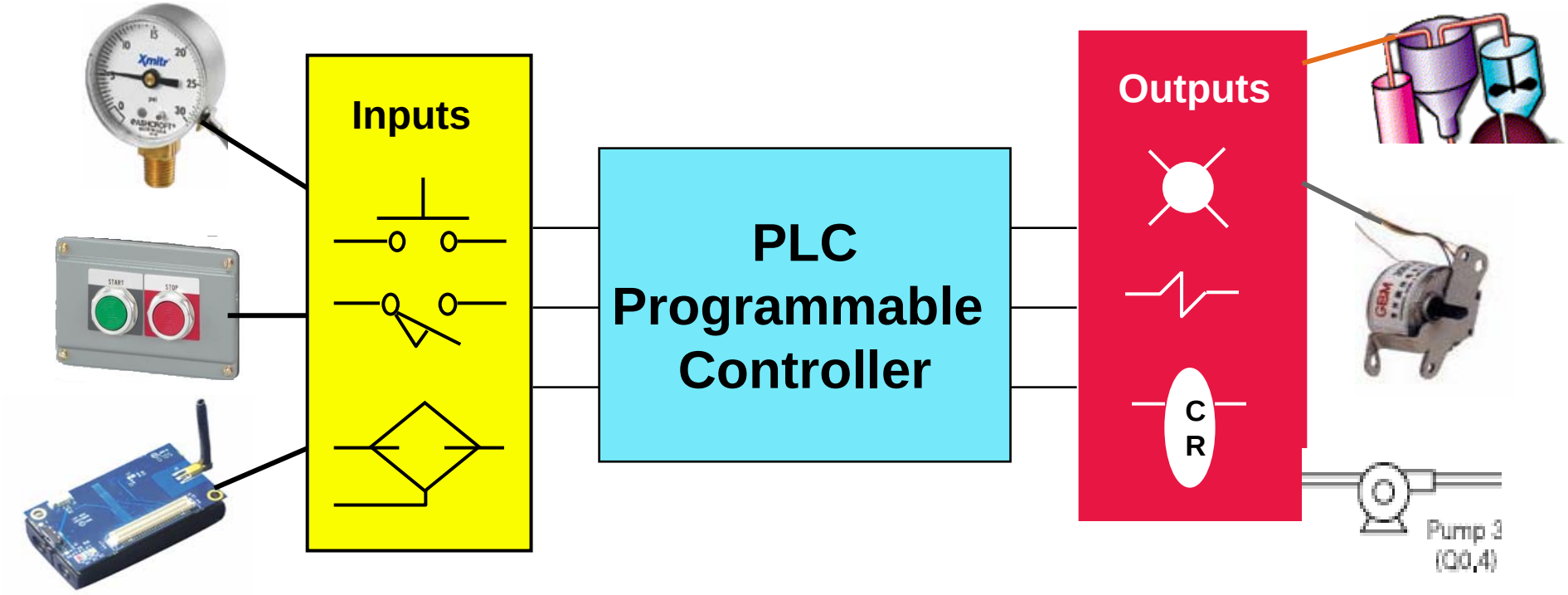
What is a PLC

- PLC = Programmable Logic Controller

- Is the workhorse on the factory floor
  - » Creates the actual "widgets" - drills, cuts, welds, …
  - » Moves the created widgets to assembly lines - conveyors, lift systems, cross-transfers, turn tables, …
  - » Counts and packages the assembled widgets - photo-counters, filling machines, weighers, packaging machines, …



PLC Usage Detail



Sensors

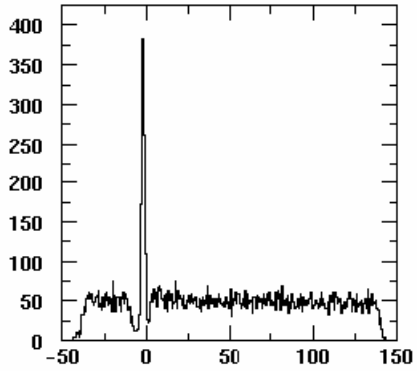
Actuators

Input ⟶ Process ⟶ Output

It's like RPG on steroids !

What is a DAQ

- DAQ = Data Acquisition system
  Acquisition (or output) and processing of analog signals and waveforms for:
  - » Temperature
  - » Pressure (air or liquid)
  - » Force or Strain, . . .



- Principally used for Test and Measurement. Output is to a "Data Log". This log is often then exported in Excel format.

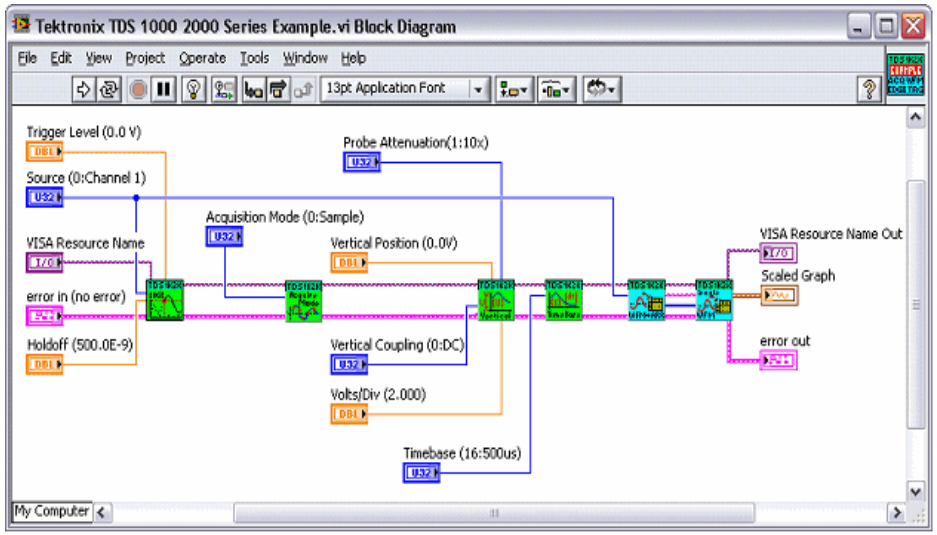
- Usually dependent upon a control computer/PC (e.g. a DAQ is basically a dumbed down PLC)

Simple to Complex

How are these things Programmed

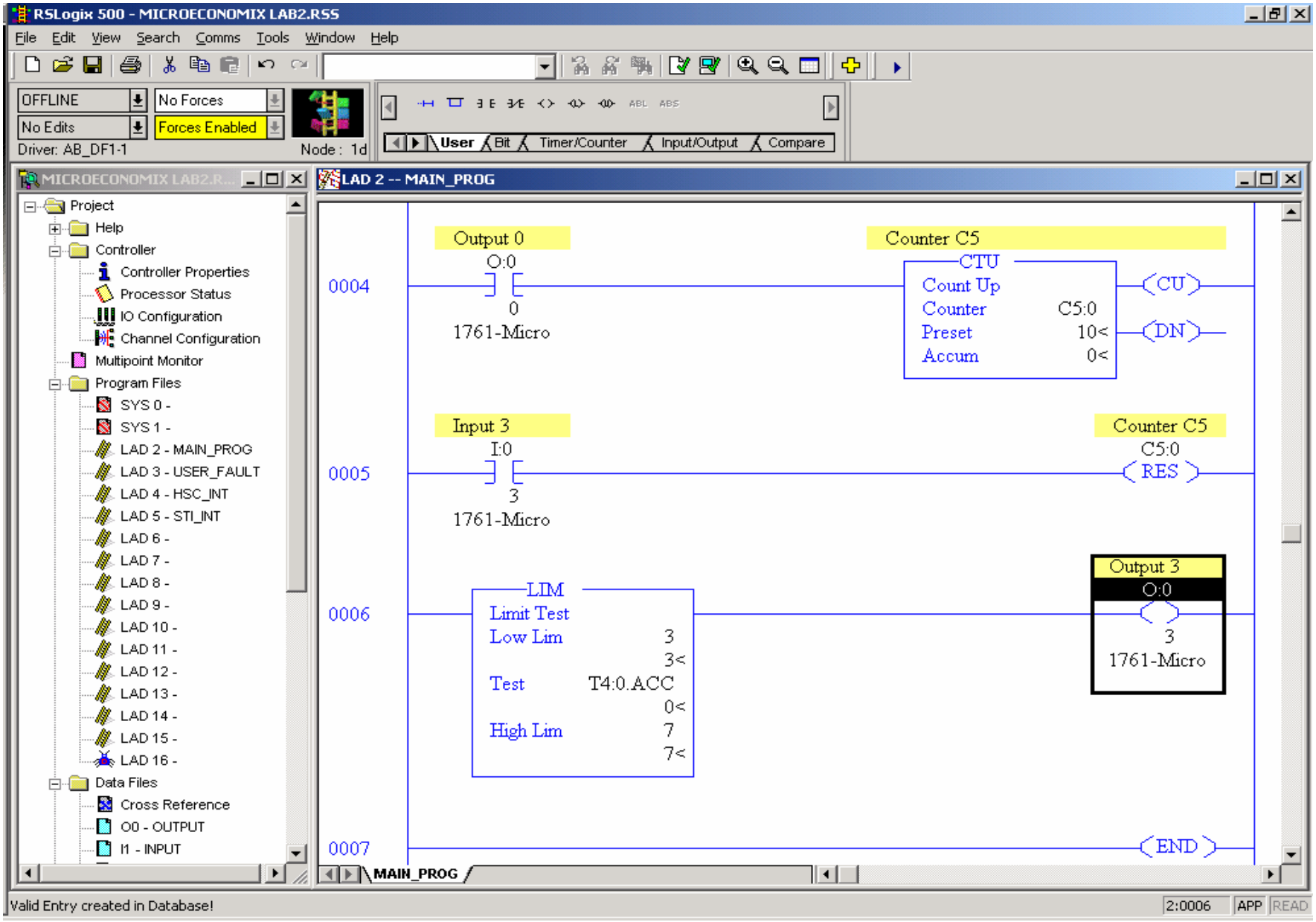
- DAQs - mixture of graphical and procedural tools
  - » LabView - primarily a visually oriented language with some parallelism
  - » SCPI (Standard Commands for Programmable Instruments), or
  - » Visual Studio.

Labview Example



- PLCs - typically Ladder Logic programs (90% of PLC programs)
  - » Visually oriented programming language
  - » Oriented to handle parallel process flows
  - » Gets clumsy when try to do "motion control" (2 and 3 axis movement)

Sample PLC Ladder Logic Program



How are these things controlled

- **SCADA = Supervisory Control And Data Acquisition**
  - » Collects data from various sensors, and then sends this data to a central computer which then manages and controls the data and processes in real-time.
  - » SCADA systems monitor and make on-the-fly changes to allow the various machines and processes to function optimally.
  - » SCADA systems are normally "closed loop systems" and run with relatively little human intervention. ("Things talking to Things")

- **The three most critical aspects of SCADA**
  - » Communication
  - » Data Logging (usually flat files, but should be moved to DBMSes)
  - » Data Display/Control (HMI - "Human/Machine Interface")

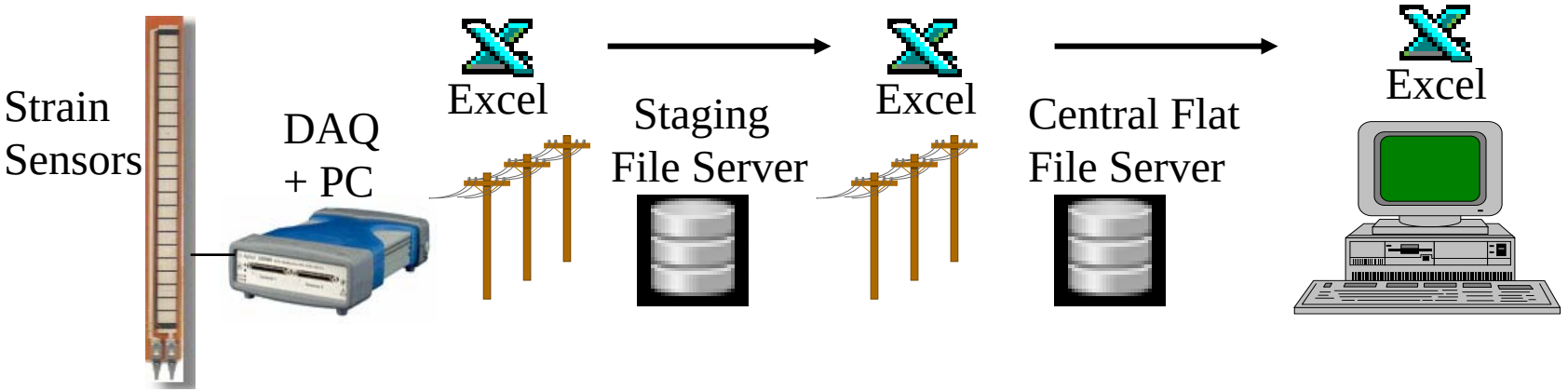
- **Primary Communication methods to/from SCADA**
  - » DAQs: usually connected via Ethernet, USB, GPIB, RS-232, or VMEbus.
  - » PLCs: usually connected via Ethernet or RS-485

Key Issues

- Proprietary, proprietary, proprietary + Lack of Open Source Tools
  - » **Multiple competing Communication standards to interconnect devices**
    - – Allen-Bradley: DeviceNet/EtherNetIP
    - – Siemens: ProfiBus/ProfiNet
    - – GE/Fanuc: Modbus-RTU/Modbus-TCP
  - » **Poor integration with Databases + Lack of Generic Tools for DBMS**
    - – Most of "logged" output data is in Excel CSV format from SCADA system
    - – Limited choice of OS/Database (Windows/SQL Server)
  - » **Poor integration with Transaction systems**
    - – World is going to JIT, but most manufacturing systems are still islands using one-way Gateways (output data sent to SCADA)
  - » **Poor integration with the Web**
    - – Web Services - what's that ?

And Shoemaker's Children is Still Common

- Critical new material needs to be tested for design+manufacture
  - » Material needs to be tested/analyzed in many different configurations
  - » Each test results in 100-300 data points, is then saved in CSV format file.
  - » Flat CSV files are sent from Staging Server to a Central Flat File Server. Typically takes 1 to 3 days for the test data to finally be available.
  - » Engineers pull CSV files off of the Flat File server and use Excel macros to tweak and plot the data.
  - » Results are then combined into a Central Design Guide used by Designers and Manufacturing.
  - » 1970s based Flat-File Orientation rules ! Databases ? Web Services ?



It's just like the 1970's DBOMP, but now with Spreadsheets !

What my current work involves

- Objective = provide an "open" common environment for E-Manufacturing that combines Web, Database, and SCADA
- Integrating key E-Manufacturing communication standards into PHP - EtherNetIP, ModBus_TCP, ProfiNet.
- Adding "Record Mode" support to PHP.
  Most PLC/DAQ data is "record" or "struct" oriented, not text.
- Modeling SCADA/HMI Machine Control as Web Services under PHP
- Why PHP ?
  - » Because it dominates the Web.
  - » It's open and does a good job integrating Web and DBMS