Interfacing the ControlLogix PLC Over EtherNet/IP

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Allen-Bradley ControlLogix

- Used on SNS HPRF Xmtr & Mod/PS, Vac., RCCS, Cryo, Facility, ...
- Symbolic ‘tag’ names: ‘ValvePos’ instead of ‘I10:12’
- Multithreaded
EtherNet/IP and ControlLogix

- **EtherNet/IP** = Industrial Protocol
- Started as “ControlNet over Ethernet”
  - Open DeviceNet Vendor Assoc., http://www.odva.org
  - CIP via TCP & UDP (Ctrl. & Info. Protocol, similar to DeviceNet)
- ControlLogix: Allen-Bradley specific CIP extensions
  - Service codes to Read/Write tags; Multiple requests
  - Access to any tag in “Controller” scope w/o modification of PLC code
  - Round-trip TCP request/response mechanism. Subscription (triggered updates via UDP) not implemented/documented for ControlLogix
Driver Design

- ANSI-C protocol routines, Win32 & Unix command-line test tool
- vxWorks driver
  - Handles registration of PLCs, tags and callbacks
  - Combines array element requests \( a[2], a[3], a[5], a[N] \Rightarrow a[0..N] \) (limited to \( \sim 500 \) bytes)
  - Launches one communication thread per PLC
    - Processes tags on periodic scan lists (1Hz, 10Hz, …)
    - Independent from e.g. EPICS DB scan tasks
    - Reads from PLC unless tag is marked for one-time write transfer
    - Combines transfers to minimize read/writes (up to \( \sim 500 \) byte PLC buffer limit)
  - Handles timeouts, attempts to reconnect on error
EPICS Device Support

- Records: ai, ao, bi, bo, mbbi, mbbo, mbbiDirect, mbboDirect
  - DTYP="EtherIP"
  - INP/OUT="@plc1 tag", "@plc2 arraytag[21]", "@plc3 struct.elem", "@plc4 Local.I5.Data[6].B7", ...
  - Tag can be REAL, INT, DINT, BOOL
  - INP/OUT can be changed at runtime to use different tag on different PLC
- Input records support SCAN="I/O Event"
  - Record processed ASAP after tag transfer
  - Requires driver scan specification in INP/OUT link: "@plc1 tag S .1" for 10Hz
Output records

- SCAN=Passive requires driver scan rate in OUT link
- Record processed ⇒ Driver writes to PLC during next scan (driver’s scan rate ⇒ max. write delay)
- Tag changes on PLC (e.g. via PanelView) ⇒ Record is updated & processed
- Avoid bi-directional use of arrays since whole array is written when ≥ 1 element changed.

Flags for ai records provide statistics: min/max/last scan times, #errors, ...

Elementary flag ‘@plc1 xy[342] E’ to avoid array transfer
Performance

- Single tag:
  11ms with default
  “System Overhead
  Time Slice” of 10%;
  7ms with 50% SOTS

- PLC & 1756-ENET/A limit

- Scalar time ≈ array time

- Combined transfers hardly affect speed

- Histogram: 3 days,
  1 x BOOL[352] @ 10Hz,
  3 x REAL[40] @ 2 Hz
Conclusion

- EtherNet/IP is convenient, uses standard Ethernet hardware
- vxWorks/EPICS support works
  - Published protocol limited to read/write known tags. No tag browsing or other RS Logix 5000 features.
  - Arrange data in arrays up to ~350 BOOLs, 40 REAL/INT/DINT for better performance.
  - Alias array elements to meaningful names for ladder logic: “ValvePos” ⇒ “Xfer[23]”
  - Keep arrays unidirectional
  - SCAN=I/O Intr minimizes read delay for input records
  - Transfer time is predictable but not guaranteed
  - Handle critical timing for e.g. “open for 0.5 seconds” in PLC, exchange command/response via Ethernet