

TCO305 - TCP/IP Control System Interface Development Using Microchip Brand Microcontrollers

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If you can see this.....

.....the remote works!

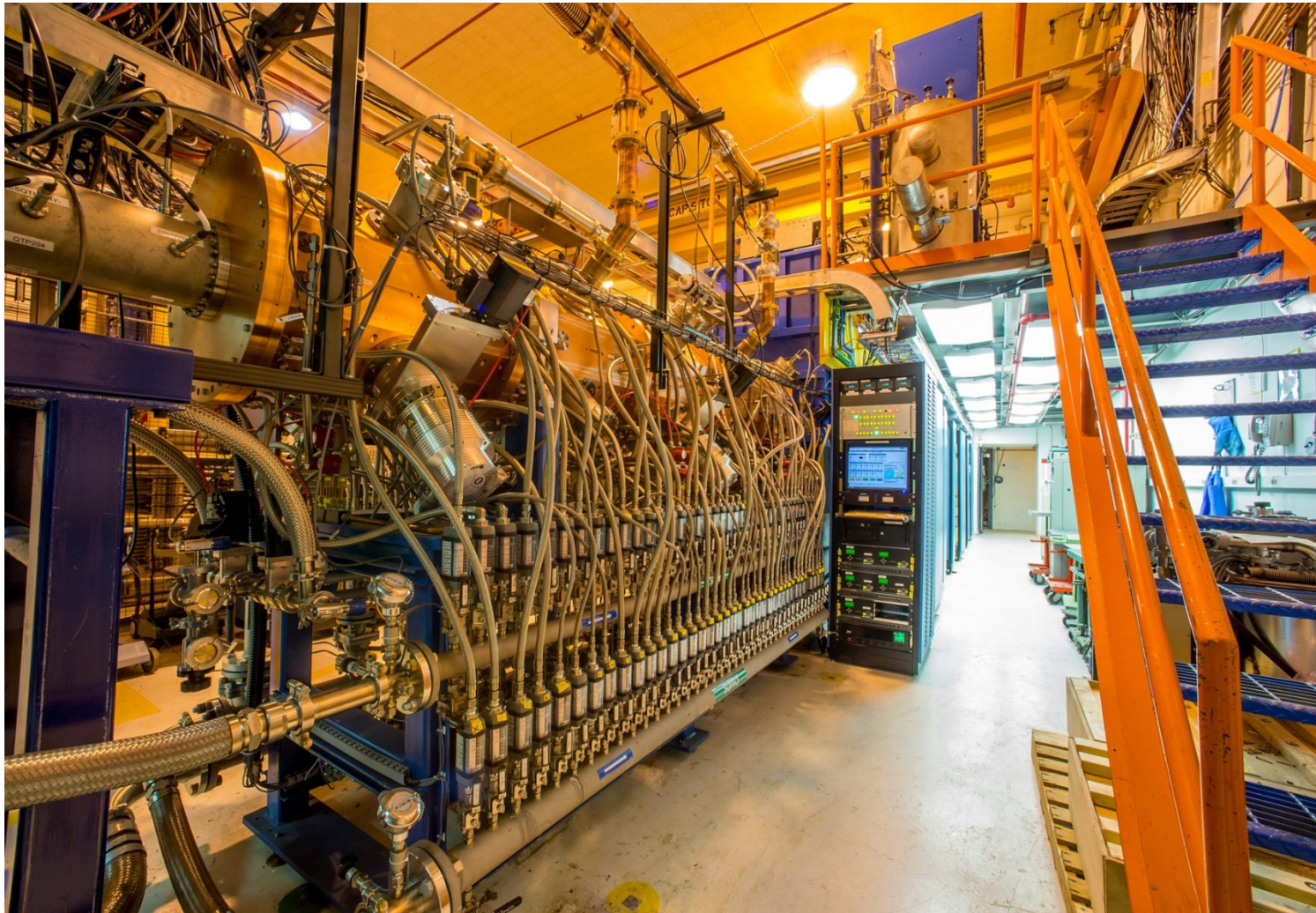


Introduction

- Thank You for having me!



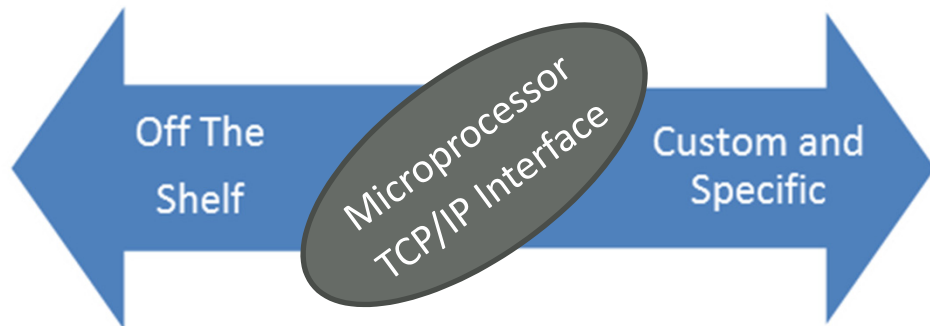
What do we do at Argonne?



Argonne Tandem Linear Accelerating System

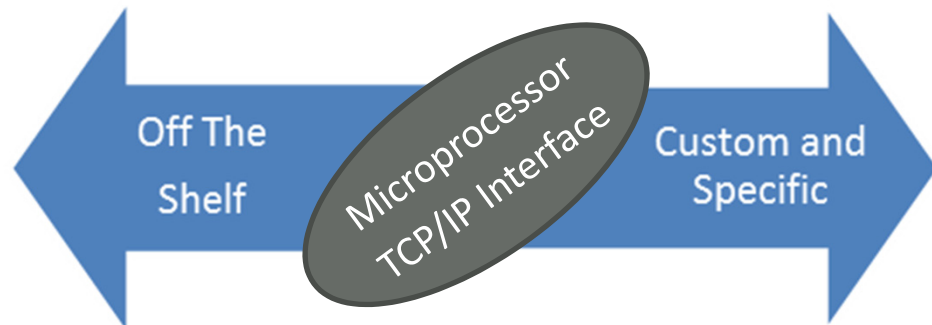


What Is the Goal of this Work? What is NOT the Goal? ○

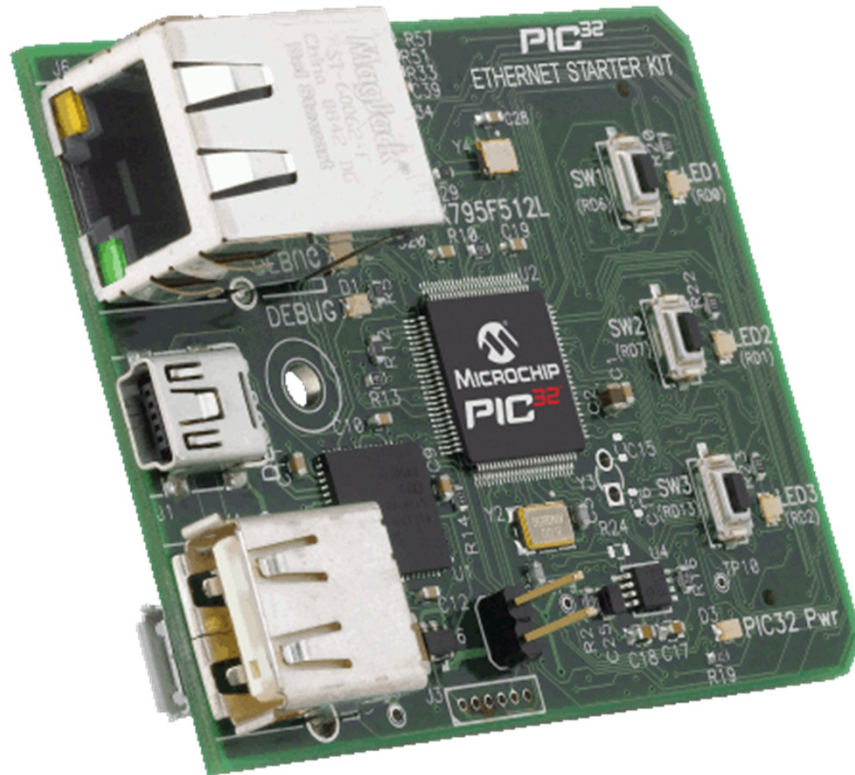


What Is the Goal of this Work? What is NOT the Goal? ○

- Push Control Systems lower into Hardware Layer
- Eliminate Expensive Custom Cabling
- Only for low speed, low resolution devices (for now)
- NOT to imply One-Size-Fits-All!
- NOT to Take Credit for Microchip's Own Work
 - No author affiliations



Microchip PIC32 Ethernet Starter Kit (PIC32 ESK)

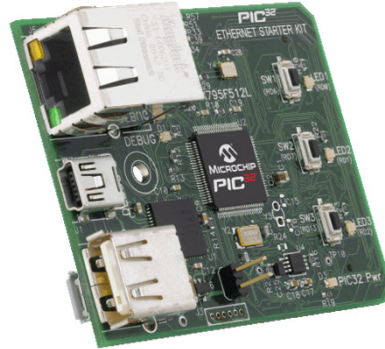


(We are really only focused on the chip itself, and PHY)

This is not the only μC that could work!

PIC32 ESK Specifications

- Clock
- RAM
- FLASH
- Cost
- Package
- Libraries
- Development Tools
- Multiple Bus Types

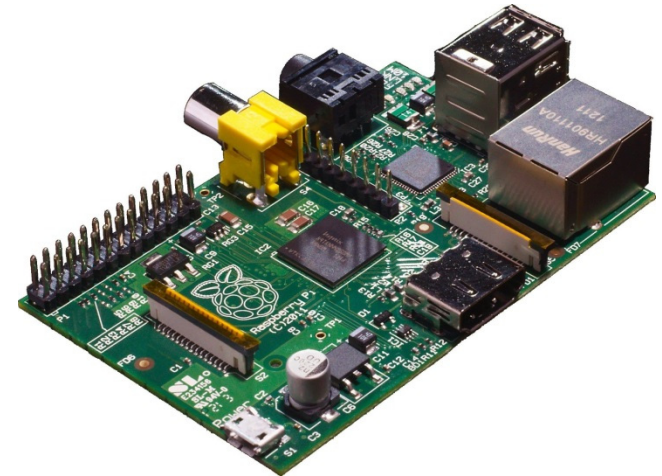
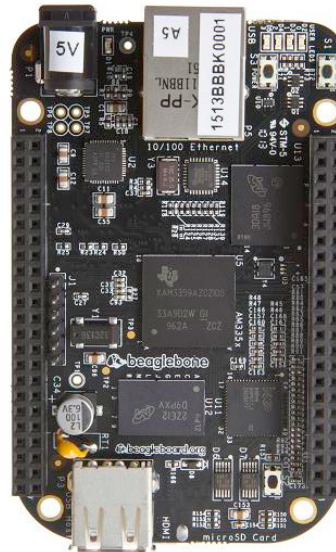


Parameter Name	Value
Family	PIC32MX7xx
Max Speed MHz	80
Program Memory Size	512 (KB)
RAM	128 (KB)
Auxiliary Flash	12 (KB)
Temperature Range (C)	-40 to 105
Operating Voltage Range	2.3 to 3.6
DMA Channels	8
SPI™	4
I²C™ Compatible	5
USB	FS Host/OTG
USB (Channels, Speed, Compliance)	1,FS Host/OTG,USB 2.0 OTG
CAN	2
A/D channels	16
Max A/D Resolution	10
Max A/D Sample Rate	1000 (KSPS)
Input Capture	5
Output Compare/Std. PWM	5
16-bit Digital Timers	5
Parallel Port	PMP16
Comparators	2
Internal Oscillator	8 MHz, 32 kHz
I/O Pins	85
Pin Count	100



Other Single Board Computers (SBCs)

- Raspberry Pi
- Beaglebone Black
- PC/104 Standard
- FPGA SoC



Are the capabilities matched with goal?

What are Some Assumptions?



What are Some Assumptions?

- Hardware Engineering Department
- Build/Design Some Beamline Electronics In-House
- Willing to Reserve PCB Space for a Custom μ C Circuit
- Have a Wide Range of Inefficient Cable Types

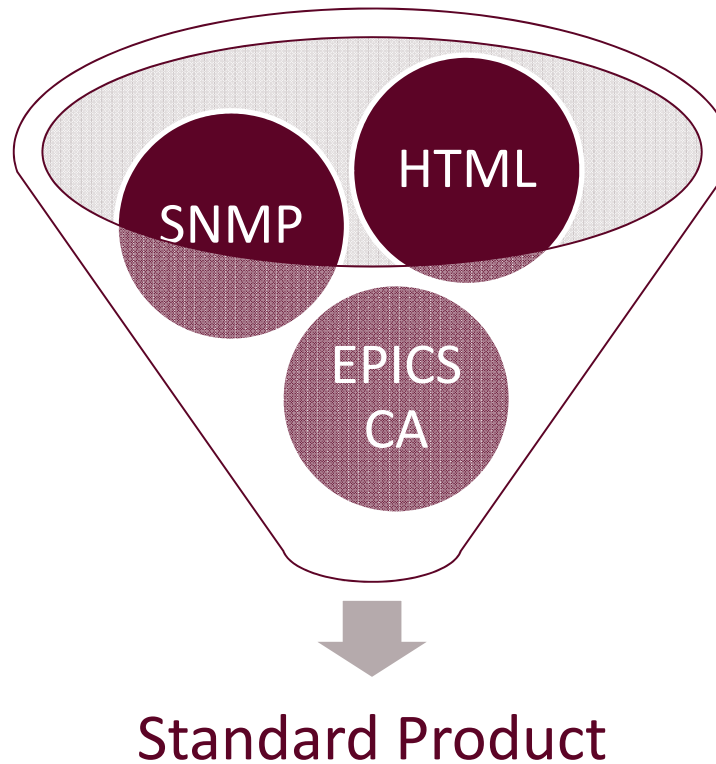


What are Some Possible Trade-offs?

Feature	Advantages	Disadvantages
Low-level on board HW communication	Configurable pin-outs speak a wide variety of HW level protocols.	Challenge to create a single standard interface design.
Small, Low Cost and native real time.	Hardware Engineers can integrate directly into end products.	Initial work for custom PCBs to distribute signals
Few Running Application sections and services	Low security risk & risk of bad behaviour as a result of complex operating system.	Requires some knowledge of Firmware development.
Increases in memory and processor speed	Can support TCP/IP stack, and has OEM software libraries	Less memory and processing power compared to SBCs.

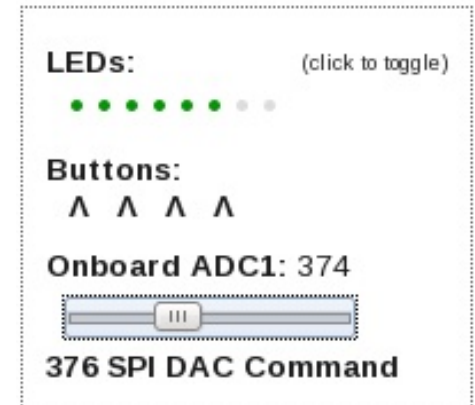
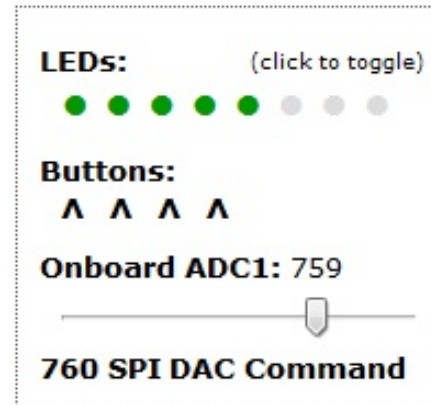
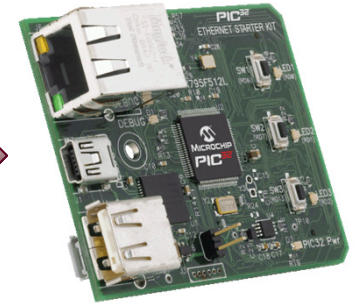


First Results Towards Integration



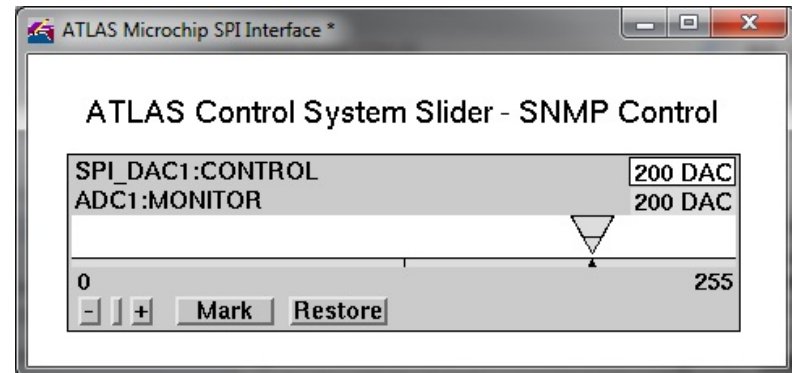
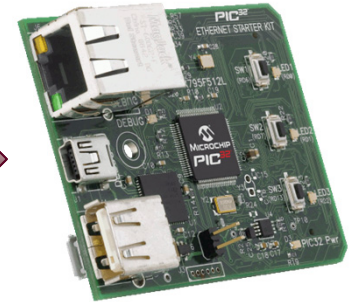
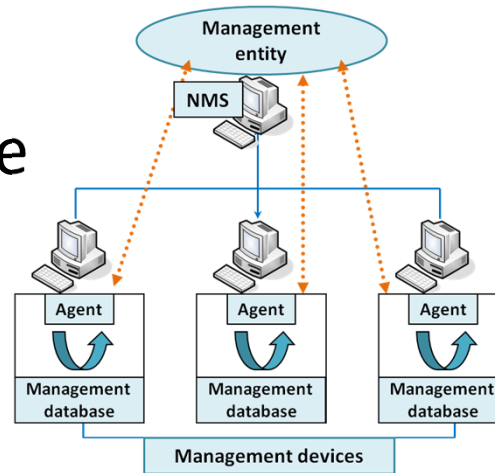
What did we do? - Basic HTML/AJAX Slider

- Implemented an HTML5 'Slider' Control
- On top of Existing HTML Server
- Not unique, but easy
- Effective for Diagnosis and Debugging
- This is PCaPAC



What did we do? - Basic SNMP Interface

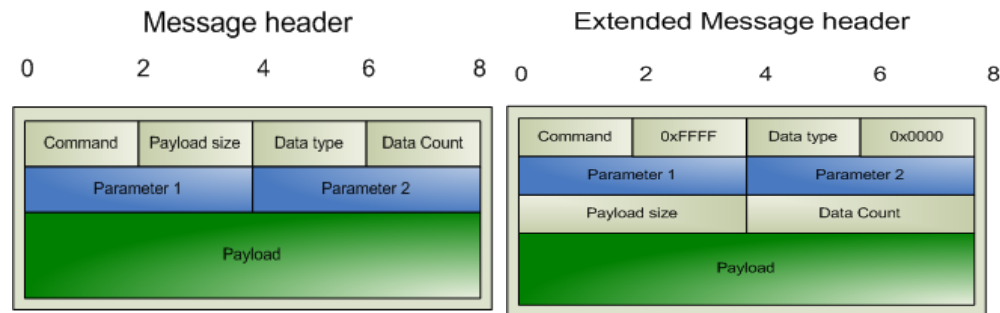
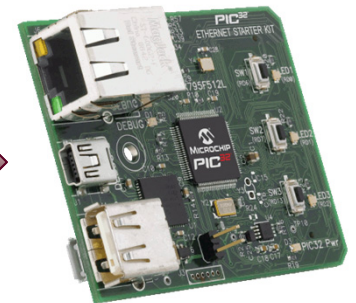
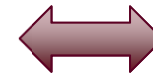
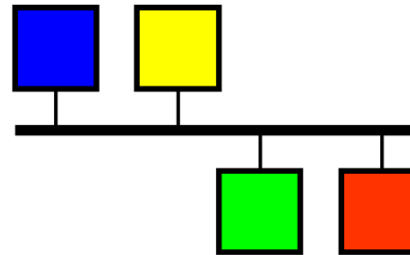
- Implemented via SNMP Handlers inside of Control System
- On top of Existing SNMP Server
- Can execute synchronously (gets) or asynchronously (traps)



What did we do? - Partial EPICS CA Integration

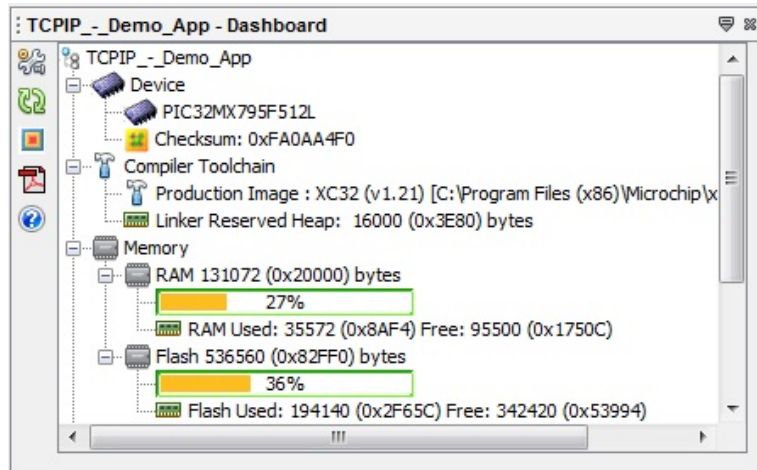
- UDP for name resolution and TCP for virtual circuits
- Ported from C based 'rsync' library
- Implementation based on Channel Access protocol specification
- Some compromises...

EPICS



Costs and Performance

- PIC32 to Terminal data payload of > 1 MB/sec
- Only dropped by ~5 KB/sec during load tests
- TCP window sizes probably still need adjustment



Component	Cost
PIC32 Ethernet Starter Kit (ESK)	70 USD
ESK I/O Expansion Board (Optional)	70 USD
PIC32MX795F512 Processor Only	11 USD
TI DP83848C PHY Chip	6 USD
MagJack Ethernet Plug SI-60000	5 USD
Beagleboard Black	55 USD
Raspberry PI Ver-B	35 USD



Next Steps for this Work....

- Actually integrate into an in-house PCB!
 - We do have Electronics Group buy-in
- And/Or develop a custom PIC32 Carrier board
- Further refine Firmware, continue to eliminate extra services. Verify responsiveness.
- Test other Microprocessors



Conclusions?

- Once you have Electronics Group 'buy in'



Conclusions?

- Once you have Electronics Group 'buy in'

**Open Source
Libraries**

**Better
Resource
Separation**

**Low Cost
Solution**

**Only CAT5
Cables**

**Huge I/O
Library**

**Standard
Configurations**

Natively

**Hardware
Familiarity**

Real Time

**Highly
Stable**

**Higher
Security**

**Internet of
Things**

**Zero Unneeded
Services**

A solution better matched to solve the problem!

Questions? Comments?

