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A Simple Architecture for Embedded Web Servers

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Agenda

What to expect…

- Embedded applications usability
- Embedded systems paradigm
- Embedded Web server architecture requisites
- 8051-type architecture implementation
- 8051-type architecture benchmarks
- Summary

Embedded Applications

- Home automation
- Industry automation
- Security systems
- Vending machines
- Network appliances

… routers, switches, security sensors, energy monitors …

Hewlett-Packard Patent

"Embedding Web access mechanism in an Appliance for user interface functions including a Web server and a Web Browser"

September 21, 1999 - Patent

… enables in the device:

- Low development cost
- Widely accessible
- Enhanced user interface functions

Embedded Systems Paradigm

- Flexible and easily network integrated
- User getting closer to the device
- Connected to the Internet
- Remotely controlled
- Extensible and standard API
- Modular components

A Web access mechanism has it all …

Networking Technology

Industrial Vs Internet

… Powerline, RS485, RS232, CAN, I2C

… IEEE 802.3, ARP, TCP/IP, HTTP

- Real-time Vs Online-time
- Reliability and efficiency
- Maintenance and support
- Proprietary Vs Open solutions
- Economical cost

New Devices - Advantages

- Standardized network access
- Standardized interface
- Modular API design
- Increased functionality
- Development low cost
- Large-scale production

… companies are now able to connect large-scale networks to embedded devices using 8 and 16 bits microcontrollers such as 8051-type.

Conventional Web Server

Functional characteristics are to serve …

- Static content (pages/documents)
- Dynamic content (pages)

… as response to an URL.

(…) Conventional Web Server

Architecture key points:

- Simple I/O file system … for storage
- Small memory footprint … for search & replace
- HTTP communication model… to serve the content
- Memory cache … could be an advantage
- Virtual memory … is not a requirement
- Simple processing unit … for page processing

… this describes the basic framework.

(…) Conventional Web Server

… but what if host-type is embedded ?

- File system is not supported
- Restricted communication model

… a possible solution …

- Flash memory
- ?!

Would it be possible to host a Web server in an embedded 8051-type architecture?

8051-type Implementation

- LAN controller (IEEE 802.3)
- MPU controller
- RJ45 connector (10/100 Mbps)
- HTTP/TCP/IP/ARP stack
- API

Such as …

- Cygnal C8051F005

8 bits, 25 MIPS, 12 bit A/D, 2.4 KB RAM, 32 KB Flash

- Crystal CS8900A

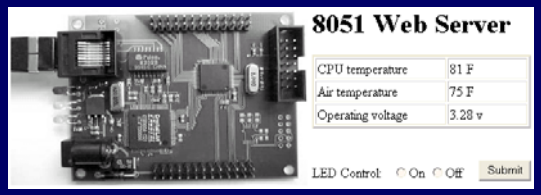
16 bits, 4 KB RAM

TCP/IP Stack - Limitations

- One receive and one transmit buffer
- No reassembling of fragmented IP frames
  - → TCP maximum segment advertise of 100 bytes
- Discard out-of-order TCP segments
- No support for IP type-of-service options
- No support for IP security options

… compatibility is achieved by implementing only the important parts of the protocols, but also due to the tolerance of other stacks.

Sample Web Page



Page Total = 7 KB

HTML tags = 0.8 KB

JPEG image = 6.2 KB

Web Server - Benchmark

Servers response time comparison:

- 8051-type embedded, Custom Web server - 60 ms
- 100 MHz Pentium, Apache Web server - 32 ms

Client:

- 500 MHz Pentium, Microsoft Internet Explorer 5.5, browser network delay - 8.5 ms

... reference value of 100 ms/page for human consumption.

(...) Web Server - Benchmark

Task	Times Run	Time (ms)
Search and replace tags	6	23.8
Copy buffers	8	9.1
Write to CS8900A	11	4.6
Parse incoming HTTP headers	2	4.5
Compute checksums	38	4.4
Read from CS8900A	8	0.6
TCP state machine	8	0.4
Total		47.4

Real Total = 47.4 + 8.5 ≈ 60 ms

... 8051 still waits for a Pentium!

(...) Web Server - Benchmark

Description	Code Space (KB)
TCP/IP	9.5
Web Page (plus image)	7.0
HTTP Server	3.8
ARP	2.5
C Library	2.9
UDP	1.4
CS8900A I/O	1.0
RS-232	0.5
Analog	0.3
Priority Task Switcher	0.3
Total	29.2

Server code = 22 KB, Page code = 7 KB

... 29 KB of the 32 KB Flash memory available.

Summary

- Web technology in embedded devices is a requirement for
  - Ease of use
  - High volume production
  - Standardized interface access
  - Standardized network access
- Hardware technology was already invented such as 8051-type
  - Low cost
  - Ease of integration
  - Relatively high performance

Redesign could be the real challenge ... when Traditional Industry refuses continued innovation costs!

Questions

Thank you for your presence!