Integrating SCADA Into CIS Curriculum

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What is SCADA?

- **SCADA** is the abbreviation for *Supervisory Control And Data Acquisition*.
- It generally refers to an industrial control system: a computer system monitoring and controlling a process.
- The process can be industrial, infrastructure or facility based as described below:
  - Industrial: manufacturing, production, power generation
  - Infrastructure: water treatment, wastewater collection and treatment, oil and gas pipelines, electrical power transmission and distribution, and large communication systems.
  - Facility processes: buildings, airports, ships, and space stations; they monitor and control HVAC, access, and energy consumption.
SCADA Architecture

Diagram showing the architecture of a SCADA system, including enterprise network, workstations, printer, application server, firewall, Internet/business partners, control system, supervisory control and monitoring station, redundant application servers, engineering workstation, human machine interface (HMI), remote/local station 1, remote/local station N, control equipment, sensors, modem, handheld device, and a communications network that can be the Internet, public switched telephone network, or a cable or wireless network.
SCADA Market

• Oil and gas: to grow at 9% over next five years; to reach almost $1.5 Billion by 2012
• Water and wastewater: to grow at 5% over next five years; to reach almost $300 Million by 2012
• Electric power: to grow at 6% over next five years; to reach almost $2 Billion by 2012
SCADA Market Decisions

- [http://tdworld.com/mag/power_trends_developments_us/](http://tdworld.com/mag/power_trends_developments_us/)

- Information Systems (IS) departments continue to play a somewhat muted role in influencing specifications and vendor selection for SCADA systems.

- Nearly half of the respondents from the current study claim that MIS has "no influence" on their SCADA-related activities.

- **Inference**: specialists in SCADA make decisions

Major Players

- GE
- HP
- Harris
- Siemens
- IBM
- Sun Microsystems
- ABB
- And many others
SCADA Developer

Source: www.monster.com

• Experienced SCADA system developer with excellent C/C++ skills in a Windows .Net environment.

• Experience with MSSQL Server and Visual Source Safe are desired.

• Good communication skills and Microsoft Office required.

• Hands-on experience maintaining and implementing the BSAP protocol is a plus.
SCADA Systems Integrator

Source: www.monster.com

- Customer service orientation, professionalism, loyalty, …
- Technical competence for functioning in a PLC and PC environment,
- Excellent references, excellent driving record required, …
SCADA Coordinator

Source: www.monster.com

- HS Diploma; A.S. degree or equivalent experience a plus
- 5-10+ years of experience as a Control Systems Programmer or Technician.
- Oil/Gas field experience is desirable.
- Travel approximately 20%
- Coordination and supervision experience desirable
SCADA RTU Programmer

Source: www.monster.com

- Have solid experience administering/supporting SCADA/DCS Systems and Remote Computer Control systems
- Knowledge of SCADA system or equivalent DCS System
- Knowledge with programming and configuring SCADA Remote Terminal Units (RTU /PLC) and SCADA communication protocols.
- Good trouble-shooting and problem solving skills
- Good oral and written communication skills
- Degree/Diploma
SCADA Senior Software Engineer

Source: www.monster.com

- General computer skills included but not limited to such as MS Office applications, Outlook, etc. Also must have experience with AutoDesk products.
- Knowledgeable and proficient in writing and debugging of SCADA, PLC, HMI and DAC System Operations and Development.
- ISA CAP/CSE/Certification or industry equivalent.

**EDUCATION AND TRAINING**

- College graduate, equivalent trade/technical school diploma, or 5 years experience in their related area of specialty.
- Minimum of five (5) years experience working in their related areas of specialty.
- Proficient in IEC-61131-3 programming languages and various development software packages.
- Proficient in HMI development and troubleshooting.
SCADA Technologist

Source: www.monster.com

• Excellent communication skills (verbal, written)
• Ability to produce finished products from moderately detailed specifications while receiving only minimal supervision
• 1 or more years oil and gas SCADA or Instrumentation Process Control experience
• 1 or more years software development experience in C++ or C#
• Ability to adhere to formal processes, standards and total quality practices in all activities
• Working knowledge of and experience with Cygnet SCADA systems (configuration, scripting, HMI screen development)
• Experienced in scripting solutions with C# and the .NET Framework versions 1.1 and 2.0
• 5 or more years oil and gas SCADA or Instrumentation Process Control experience In depth knowledge of VB scripting
• Preferred Bachelor’s Degree in Electrical or Computer Engineering or related Computer Science or Information Systems field
SCADA Opportunities

• Average Salary: greater than 50K;
• With experience: > 100K
• Hourly wages: $40 or more
## Analysis of Requirements

<table>
<thead>
<tr>
<th>SCADA-related Skills</th>
<th>Protocols (BSAP, others); Basic knowledge (PLC, RTU’s, HMI); System knowledge (oil/gas, control systems, process control, Cygnet) Specialized knowledge (IEC-61131-3 programming experience)</th>
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<tr>
<td><strong>Programming Skills</strong></td>
<td>C/C++/C#, VB, .NET, MS SQL, Visual Source Safe</td>
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<tr>
<td><strong>Others</strong></td>
<td>Communication skills (verbal and written), problem-solving skills, trouble shooting skills, supervision</td>
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# Where do we Teach Skills?

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<th>SCADA-related Skills</th>
<th>Protocols (BSAP, others); Basic knowledge (PLC, RTU’s, HMI); System knowledge (oil/gas, control systems, process control, Cygnet) Specialized knowledge (IEC-61131-3 programming experience)</th>
<th>PLC’s are taught in some EE courses; HMI is taught in some CS/CIS courses; Others??</th>
</tr>
</thead>
<tbody>
<tr>
<td>Programming Skills</td>
<td>C/C++/C#, VB, .NET, MS SQL, Visual Source Safe</td>
<td>Most of these covered by programming and other courses in CS/CIS</td>
</tr>
<tr>
<td>Others</td>
<td>Communication skills (verbal and written), problem-solving skills, trouble shooting skills, supervision</td>
<td>Liberal arts courses, upper division CS/CIS courses, project management courses</td>
</tr>
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</table>
Current SCADA Education Opportunities

• Mostly private training companies/institutes
• Several online courses

Following blog post (July 2008):

• “I'm considering participating in an online based SCADA course that covers 12 modules over 3 months including DNP (3), other protocols for Fieldbus, LAN and WAN among various other topics and example of real life scenarios. It's called a certificate in Modern SCADA communication systems by IDC Technologies.

The price for the course is over 1000 euro but I don't think that's too bad for the amount of topics covered.

I was just wondering if anyone had any experience of these type of courses if not this one specifically and had any good/bad stories about them...”
Managers of SCADA systems and industrial networks are at a crossroads, tempted by new developments in technology but cautious because of their mission-critical responsibility. This three-day training course is designed to present SCADA and Industrial Computing personnel with a clear understanding of just how their environment is being redefined as a result of revolutionary changes in supporting technology.
Syllabus

• Telecommunications Services and Link Protocols
• Local Area Networks in The Master Station and in The Field
• Principles of The TCP/IP Architecture
• Reliability, Redundancy and Safety Issues
• Features of the RTU
• PLCs and Industrial Computers
• Instrument and Equipment Interfaces
• Features of the MTU/HMI
• Security
• Data Historian/Backend Systems
• Planning and Managing SCADA Projects
PETEX (UT)

Syllabus

- Introduction to SCADA
- Real time systems
- Remote control
- Communications
- Radio and wireless
- Remote terminal units (RTUs)
- Process interface equipment
- Master terminal units (MTUs)
- SCADA applications
- Operator interface
- SCADA economics
- Next SCADA improvements
- Cost: $1,160 for 2.5 days’ training
National Importance

- Critical infrastructure protected by SCADA systems
- Reliability of SCADA extremely important
- Security of SCADA extremely important
- Very little standardization
Core Competencies

- Programming
- Embedded systems
- HMI
- Networking
- Architecture (system and software)
- Project management
- Domain aspects (interdisciplinary)
Historical Development of Programs

• Technology Development
• Critical mass of use in industry
• Availability and use on campuses
• Training by specialized departments
• Availability of introductory books for academia
• Development of curricula
• Adoption by existing departments
• Creation of new departments (graduate and undergraduate)
• Exponential growth of industry due to availability of trained personnel
Example: Computer Science

- Technology: 1945 onwards
- IBM supplied IBM 650 to campuses in the 50’s
- First CS course taught at Stanford in 1955
- Evolved from Department of Mathematics
- First book appeared in the 60’s: *Computer Science: A First Course* by Alexandra Illmer Forsythe
- ACM 1968 Curriculum appeared
- Computer Science Departments formed for teaching primarily graduate students
- Toward end of 70’s undergraduate programs offered
- Impacted positively growth of several industries
Example: Information Systems

- IS professionals must have a broad business and real world perspective.
- IS professionals must have strong analytical and critical thinking skills.
- IS professionals must have interpersonal communication and team skills and have strong ethical principles.
- IS professionals must design and implement information technology solutions that enhance organizational performance.
- Availability of books
- IS’97 Curricula
- MIS and CIS programs developed
Example: Gaming

- Exists for the past 30 years
- Has grown exponentially in recent years
- Current sales more than $10 Billion in the US
- Courses offered by Department of Communication (Trinity College), Arts (Art Institute of Phoenix), CS (UWashington), CIS (UPenn)
- Degrees also available: Game Design and Development at Brown College (3 year BS degree) in their School of Technology
What about SCADA?

• Industry about 40 years old
• Technology used in several industries in many different countries
• Technology available in academia: control of entrances/exits, electricity, water supply
• Lab equipments available
• Courses?
• Which department should take responsibility?
## Comparison Between Programs

Source: [http://www.sba.udayton.edu/mod/mis/comparison.asp](http://www.sba.udayton.edu/mod/mis/comparison.asp)

<table>
<thead>
<tr>
<th>Focus</th>
<th>MIS</th>
<th>CIS</th>
<th>CS</th>
<th>CEng</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective</td>
<td>More efficient or effective organization</td>
<td>Reliable computer program</td>
<td>Better computer technology</td>
<td>Improved engineered product</td>
</tr>
<tr>
<td>Core skill</td>
<td>Problem solving</td>
<td>Logic/procedures</td>
<td>Algorithms, math, and science</td>
<td>Engineering</td>
</tr>
<tr>
<td>Core task</td>
<td>Determine business requirements for information systems</td>
<td>Deliver information systems to meet defined requirements</td>
<td>Design software and hardware tools needed to deliver on requirements</td>
<td>Determine information processing requirements of devices</td>
</tr>
<tr>
<td>Theoretical vs. applied</td>
<td>Balanced</td>
<td>Applied</td>
<td>Theoretical</td>
<td>Balanced</td>
</tr>
<tr>
<td>Generic job title</td>
<td>Architect</td>
<td>Builder</td>
<td>Tool developer</td>
<td>Architect and Builder</td>
</tr>
<tr>
<td>Typical starting job title</td>
<td>Business systems analyst</td>
<td>Application Programmer</td>
<td>System Programmer or Chip Designer</td>
<td>Engineer</td>
</tr>
<tr>
<td>Career goals</td>
<td>Senior organizational manager</td>
<td>Programming manager</td>
<td>Manager or architect of particular technology</td>
<td>Senior engineering or product manager</td>
</tr>
<tr>
<td>University home</td>
<td>Business</td>
<td>Arts &amp; Sciences</td>
<td>Arts &amp; Sciences</td>
<td>Engineering</td>
</tr>
</tbody>
</table>
Computer Information Systems

- Interdisciplinary outlook: business and CS
- Students understand programming, networking, and business domains
- Applied approach
- Can benefit from being in Engineering schools
- Increasingly popular with students
Typical Approach to Introducing SCADA in CIS

• Programming covered in first year
• Networking part of senior year
• Project management part of senior year capstone course
• SCADA basics could be an elective (junior/senior)
• SCADA lab could be an additional 1 credit elective (junior/senior)
SCADA Course Contents

- Basics
- Protocols (ModBus, FieldBus, BSAP)
- RTU Technologies
- MTU Technologies
- HMI
- System Architecture
- System Integration
- Project
- Presentation
Suggested SCADA Projects

• Design and Implement SCADA for Oil Pipeline
• Design and Implement SCADA for pharmaceutical plant
• Design and implement SCADA for a 100-storey skyscraper
• Evaluate reliability and security of a SCADA system
SCADA Lab Contents

• SCADA System Design
• SCADA System Implementation
• Interfacing systems using standards
• Development of HMI
• PLC implementation
• Integrating PLC to SCADA System
• Simulations of SCADA System Extensions
SCADA Lab Equipment

This equipment part of Critical Infrastructure Protection Center, Mississippi State University.

Director: Prof. Ray Vaughn

Lab built by:
John Gordon
Control Systems, Inc.
3822 Highway 25
Montevallo, AL 35115
Ph. 205-679-4000
An Approach for SCADA Minor

- C++/C# .NET programming (COSC 1137, COSC 4309)
- HMI (COSC 4309)
- Project management (COSC 4375)
- Networking (COSC 4325)
- Elective: SCADA + Lab
- Security (COSC 4361)
- Total: 19 credit hours
Relationship to Bloom’s Taxonomy

- Knowledge
- Comprehension
- Application
- Analysis
- Synthesis
- Evaluation

- Networking, Programming/Business Basics
- Security
- C++, VB, .NET Programming (HMI)
- Project Management, SCADA Lab
- SCADA
- SCADA Project
- Networking, Programming/Business Basics
Future (next 10 years)

- SCADA Degree Program (BS in SCADA)
- SCADA projects
- Pervasive SCADA
- Big Brother?
Conclusions

• SCADA is a rapidly growing industry segment
• Major requirement for well trained college students
• Currently very few programs exist – mostly private training academies
• Critical mass for academic programs seems to have been reached
• SCADA can be easily integrated to the CIS curriculum
• SCADA course to SCADA minor to SCADA programs is a viable path.