

A State of the Course Report: Computer Organization & Architecture

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Why Computer Organization and Architecture

- Core course by any curriculum recommendation
- Systems people are hard to hire
- Course has to be taught by someone
- Who is teaching this core material and how comfortable are they about what they are doing?

Is there a problem?

- Computer Organization/Architecture is a core course in the CS curriculum.
- Does every program have the faculty needed to teach this course?
- What is the level of expertise/confidence among faculty?
- How is the course content determined?

Web-based Survey

- Information about the institution and the department offering the course.
- Is the focus primarily on education and/or heavy research?
- How many students graduated?
- Faculty background.
- When was the course curriculum last revised?
- What, if any, curriculum guidelines used?
- Details of textbooks, class formats, gender ratios, evaluation methods, etc.
- Over 80 faculty from colleges and universities around the world responded

Curriculum Recommendations

Curriculum 1991	Curriculum 2001
AR1: Digital Logic AR2: Digital Systems AR3: Machine Level Rep. of Data AR4: Assembly Level Organization AR5: Memory System Org. & Arch. AR6: Interfacing & Communication AR7: Alternative Architectures	AR1: Digital Logic & Digital Systems AR2: Machine-level Rep. of Data AR3: Assembly Level Machine Org. AR4: Memory System Org. & Arch. AR5: Interfacing & Communication AR6: Functional Organization AR7: Multiprocessing & Alternative Arch.

Survey Questions: (Not) Taught, Confidence Level, preferred teaching method, resources used/available, etc.

General Findings

- Nearly $2/3^{\text{rd}}$ teach the course outside of their primary area of interest.
- $3/4$ of the institutions have a single designated instructor to teach the course.
- At least $1/4$ reported no significant change in course curriculum in the last two years.
- Faculty self-reported discomfort in teaching nearly 40% of the course topics.

AR1: Digital Logic & Digital Systems (6 hours)

- Overview and history of computer architecture, fundamental building blocks (logic gates, flip-flops, counters, registers, PLA): **Most feel confident teaching these topics.**
- Register transfer notation, physical considerations (gate delays, fan-in, fan-out): **¼ to 1/3 feel low levels of confidence. Only ¼ feel high confidence. Majority are not completely comfortable.**

AR2: Machine-level representation of data (3 hours)

- Bits, bytes, and words, numeric data representation and number bases, fixed- and floating-point systems, signed and twos-complement representations, representation of nonnumeric data (character codes, graphical data): **Most feel confident teaching these topics.**

AR3: Assembly Level Machine Organization (9 hours)

- Basic organization of the von Neumann machine, Control unit; instruction fetch, decode, and execution, Instruction sets and types (data manipulation, control, I/O), Assembly/machine language programming, Instruction formats, Addressing modes, Subroutine call and return mechanisms: **Most feel confident teaching these topics.**
- I/O and interrupts: **1/3 have low confidence. Nearly 3/4 have medium to low confidence in these areas.**

AR4: Memory System Organization & Architecture (5 hours)

- Storage systems and their technology, coding, data compression, and data integrity, memory hierarchy, main memory organization and operations, latency, cycle time, bandwidth, and interleaving, cache memories (address mapping, block size, replacement and store policy), virtual memory (page table, TLB), fault handling and reliability: **2/3 or more have medium to low confidence teaching this topic, in general.**

More specifically, for coding, data compression and data integrity, as well as fault-handling and reliability, **60% said they have low confidence.**

AR5: Interfacing & Communication (3 hours)

- I/O fundamentals: handshaking, buffering, programmed I/O, interrupt-driven I/O, interrupt structures: vectored and prioritized, interrupt acknowledgment, external storage, physical organization, and drives, buses: bus protocols, arbitration, direct-memory access (DMA): $\frac{3}{4}$ or more have medium to low confidence in these topics.

AR6: Functional Organization (7 hours)

- Control unit: hardwired realization vs. microprogrammed realization: $\frac{3}{4}$ or more have medium to low confidence.

AR7: Multiprocessing and alternative architectures (3 hours)

- Introduction to SIMD, MIMD, VLIW, EPIC, Systolic architecture, Interconnection networks (hypercube, shuffle-exchange, mesh, crossbar), Shared memory systems, Cache coherence, Memory models and memory consistency. **Medium to low confidence was the prevalent report in these areas.**

Summary: Areas most in need of support

- Register transfer notation,
- I/O and interrupts,
- Memory organization & architecture,
- Interfacing and communication,
- Some areas in functional organization.

Resources

- The Computer Architecture & Assembly Language Education Web Site
www.sosresearch.org/caale
- Two Special Issues of ACM Journal of Educational Resources in Computing (JERIC), Volume 1, No. 4 and Volume 2, No. 1
- NSDL/CITIDEL

- Courses
- Learning Resources
- CAALE Laboratory for Computer Science Majors: An Integrated Approach
- CSE Presentations
- CSE Working Group Reports
- CSE Working Group Participants
- Site Contributors



"What Is Computer Architecture?"
 "What is Assembly Language?"

- Testbooks
- Information Al Selecting CA Software
- Simulators
- Organizer
- People
- Applications in News
- Careers
- Conference

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The CAALE HomePage is not yet publicly announced but will be unveiled officially at a future conference (to be named later).

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[Join the CAALE USTSERV/MAJOR/COMO Email Conference!](#) (this will also provide a way to notify you for important announcements such as when is this website changes location)

Please join the computer architecture and assembly language education (CAALE) community by signing the guest book below especially if have you found something useful!

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Bill Yurcik's simulators collection

- Probably the most comprehensive index of available simulators for use in computer organization/architecture courses anywhere.
- Local view
- Why simulators?
 - Get realistic experience programming machines that strip away the excess baggage and focus on the part of the architecture you want to emphasize
 - Get experience programming machines you cannot actually own.

Beyond simulators

- Real help in overcoming weaknesses in course topics takes more than a list of tools
 - It takes a community of people ready to help
 - It takes many kinds of resources, from primary research papers to tools to laboratory exercises to good exam questions ...
 - It takes tools that help combine the resources into course syllabi and classroom activities.

NSDL

- The National STEME (Science, Technology, Engineering, & Mathematics Education) Digital Library
- \$100 M project to provide access to
 - Content
 - Services
 - Tools
 - That will support faculty and students in STEM

CITIDEL

- The Computing Education Content and Services area of NSDL
- Project involving Virginia Tech (lead institution), the College of New Jersey, Hofstra, Penn State, Villanova
- Built on CSTC and JERIC



CITIDEL - Netscape

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Location: file:///C:/Documents and Settings/cassel.CASSEL/My Documents/Presentations/CITIDEL.htm

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Welcome to the initial site for CITIDEL, a part of the [National SMETE \(Science, Mathematics, Engineering, and Technology Education\) Digital Library \(NSDL\)](#). We are developing a site and its collections that will serve the computing education community in all its diversity and at all levels. This will include computer science, information systems, information science, software engineering, computer engineering, and all other variations of title and substance in these and related fields.

- This is the initial version of this site. We currently have resources from CSTC, NCSTRL, JERIC, Computer History, and more.
- If you would like to contribute resources to CITIDEL, you may do this by submitting them to [CSTC](#).
- (new) For information about classification schemes, click [here](#).

We are currently carrying **24531** unique resources from **6** different [member collections](#).

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Conclusions

- A need exists in at least one subject area to support faculty teaching outside their area of specialization
- Resources are often available, though not always widely known
- Digital libraries are under development that will connect faculty and students with tools and materials to enhance the learning experience.

An opportunity

- Digital libraries built specifically for education are under construction and open for comment and requests
 - Speak up in person or by e-mail to share your experiences and your ideas of what would be most helpful
- Deb Knox, who runs and maintains CSTC is here. Speak to her about what would make that resource more useful.