ICS-OS: A Kernel Programming Approach to Teaching Operating System Concepts

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Outline

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- Teaching with ICS-OS
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Introduction

- Traditional approaches to teaching operating system concepts
  - Programming simulations
  - Writing user space applications
- Students are more interested in writing code that runs at kernel space
  - Write an operating system from scratch
  - Modify an actual operating system
- Emulation and Virtualization
  - Makes it easier to work with real-world operating systems

Related Work

- Minix
  - POSIX compliant
  - Used in Tanenbaum's OS textbook
- Nachos
  - Kernel and simulator run as Unix processes
- GeekOS
  - Runs on real hardware
  - Designed for simplicity
- DEX-OS
  - Runs on real hardware
  - Based on an aspect-oriented design

ICS-OS Overview

- A *distribution* based on the DEX-OS kernel
- Kernel
  - Memory-resident
  - Process management
  - Memory management
  - etc.
- User applications
- Software development kit

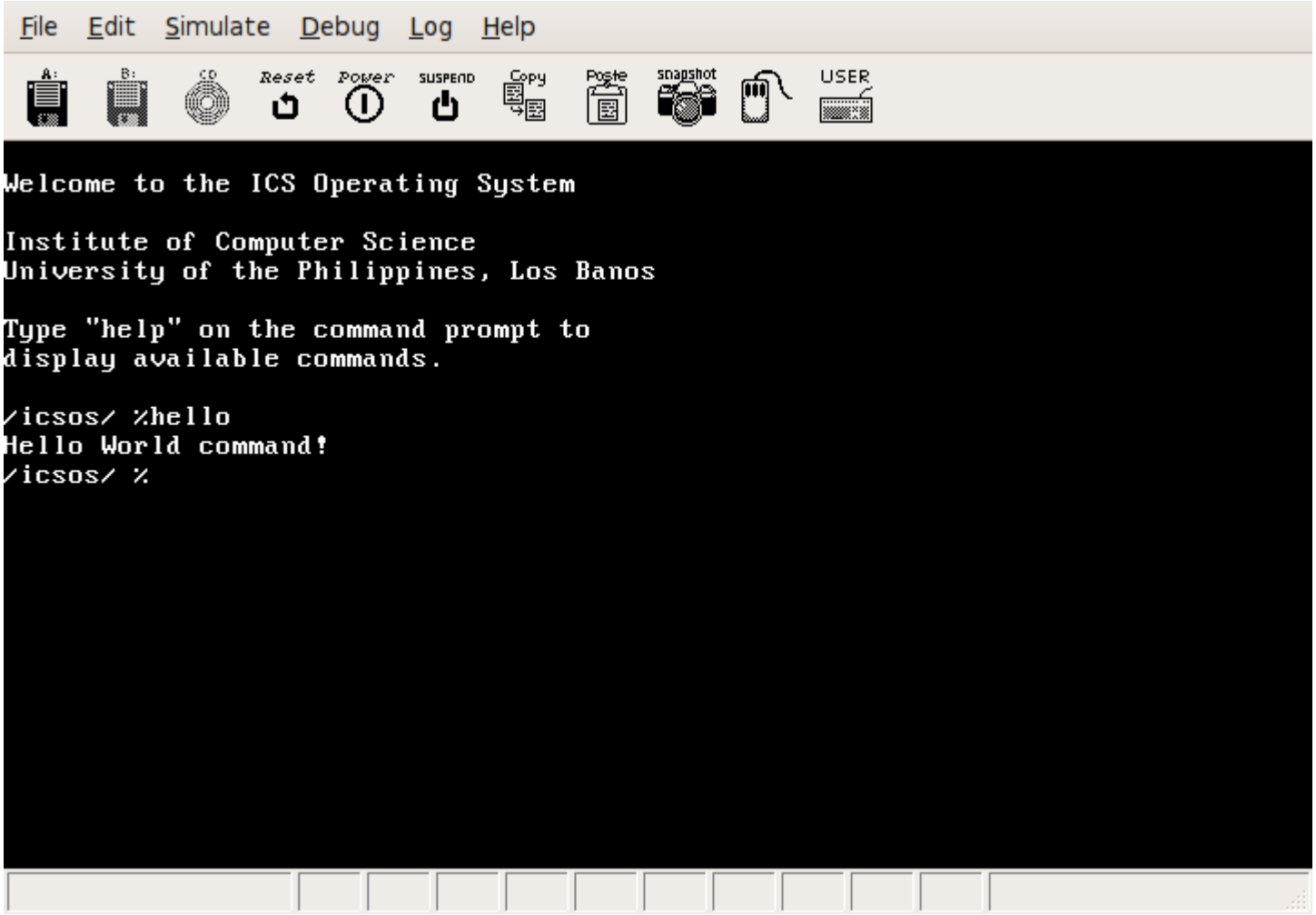
Teaching with ICS-OS

- Development Environment
  - Ubuntu
  - GNU Make
  - GCC/TCC
  - NASM
  - Bochs
  - VirtualBox
  - Subversion

```
File  Edit  View  Terminal  Help
jach@delilah:~/src/ics-os-trunk$ ls
apps          bochsrc.simple            grub.img          LICENSE      TODO
apps-old      boot                      icsos01.png       Makefile     vmdex
AUTHORS       c.img                     ics-os-floppy.img mnt
base          contrib                   INSTALL           parport.out
bochsout.txt  daily-snapshot-ics-os.sh  kernel            README
bochsrc       greeter.jpg               lib               sdk
jach@delilah:~/src/ics-os-trunk$
```

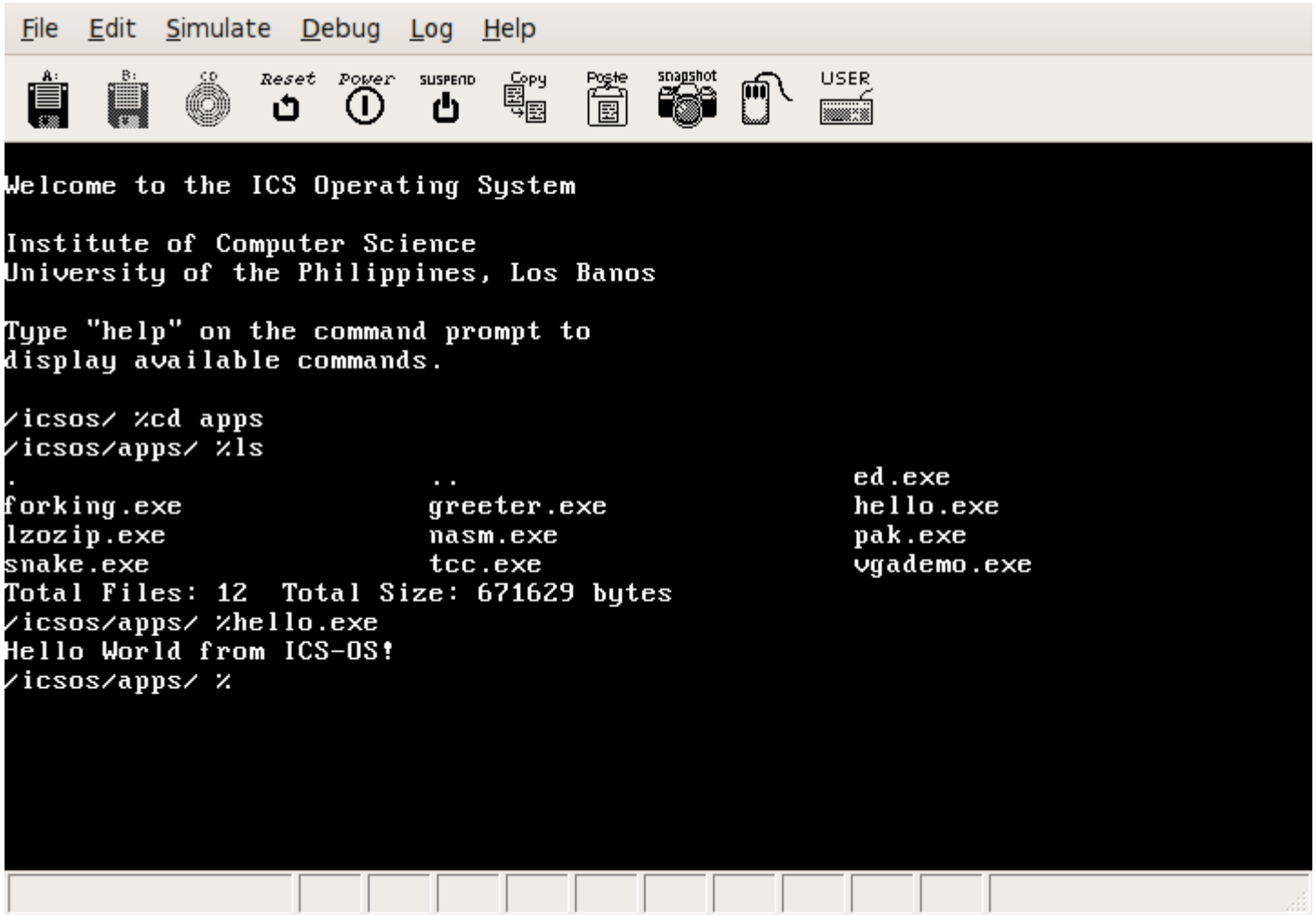
Teaching with ICS-OS

- Add new shell command



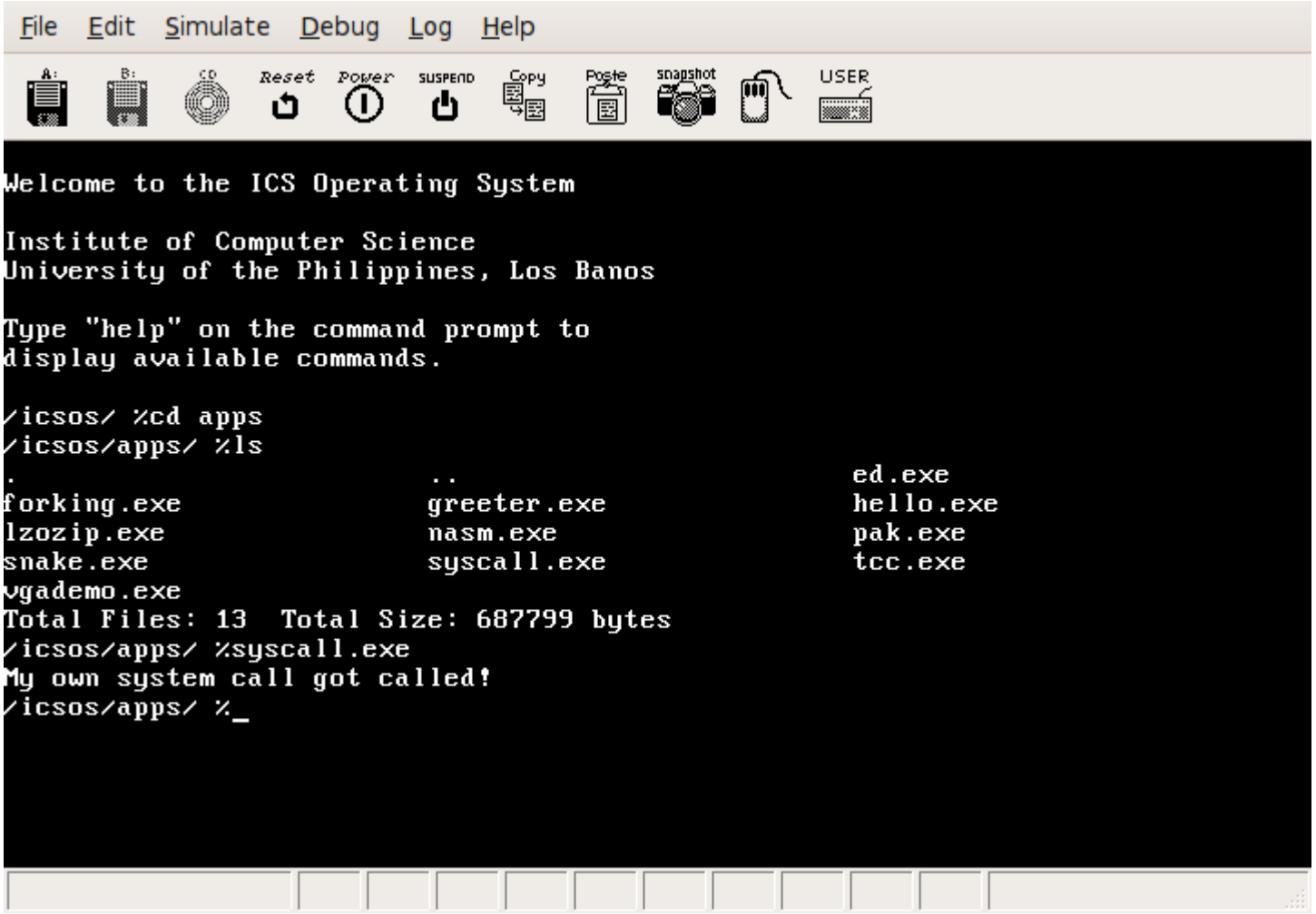
Teaching with ICS-OS

- Develop user applications



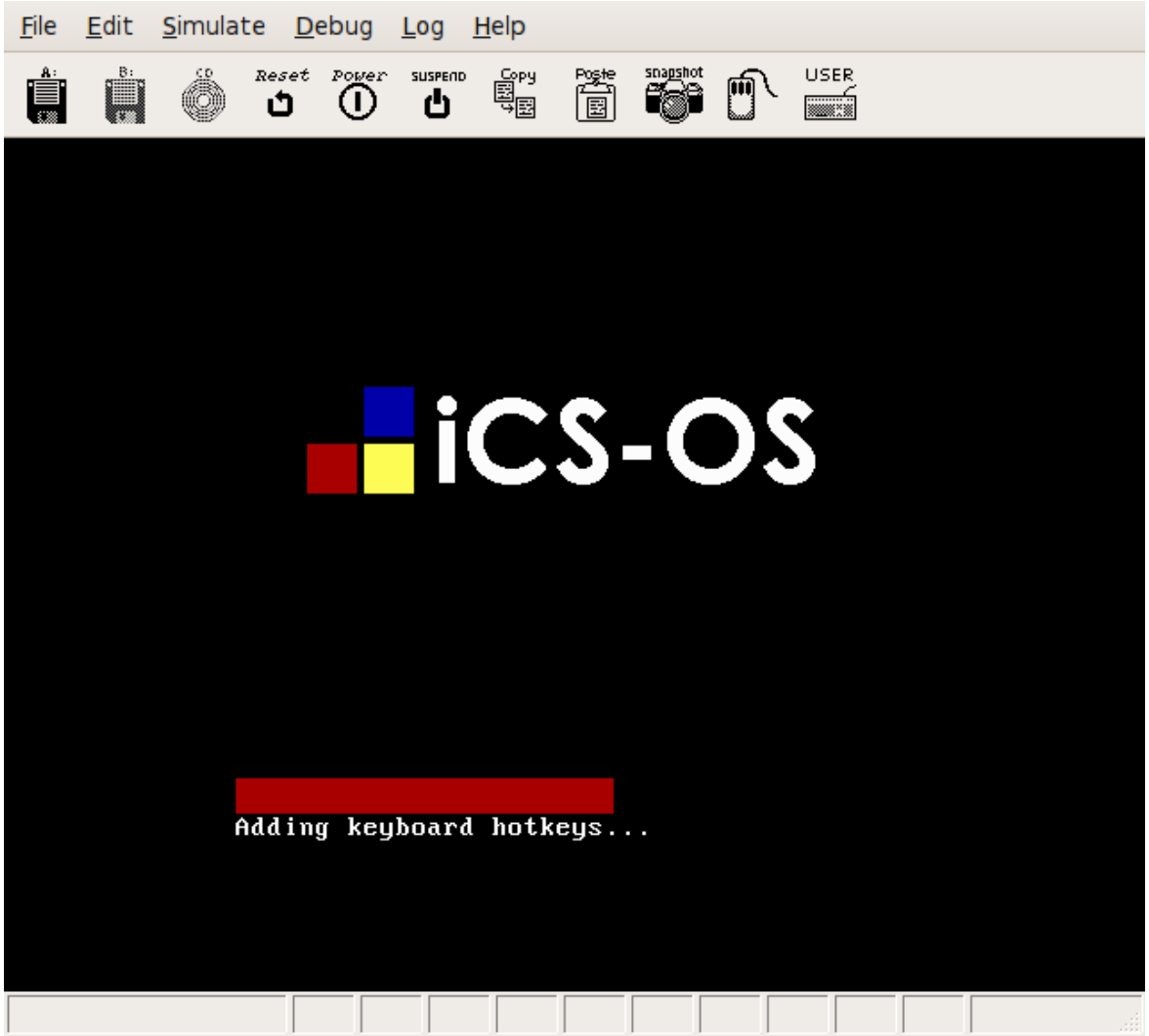
Teaching with ICS-OS

- Add a new system call



Teaching with ICS-OS

- Student Projects
  - Simple GUI
  - Improved shell
  - Text editor
  - Archiving utilities
  - Help system
  - Time/Date utilities
  - Disk utilities



Results and Observations

- Students were able to appreciate how an operating system works internally with the use of ICS-OS
- Not all students are fluent in the use of the C programming language
- Some students proposed ambitious projects
- Incomplete implementation of the C standard library

Results and Observations

- Achieved objectives for students
  - They learned how an operating system works from the bare metal
  - They were able to see the big picture on how a computer system works
  - They were able to understand the separation of kernel space and user space
  - They were able to understand how programs are loaded and how processes are created and executed
  - They were able to understand how system calls work and the importance and advantages of using application programming interfaces and software development kits

Conclusion

- In this work, the author presented ICS-OS as an instructional operating system for teaching operating system concepts to undergraduate students through kernel programming
- A high success rate in the students projects indicates that a kernel programming approach is better in making them understand how a real operating system works

Acknowledgments

- Joseph Emmanuel DL. Dayo
- Students of CMSC 125, Operating Systems, Second Semester AY 2008-2009

Resources

- http://code.google.com/p/ics-os
- http://sourceforge.net/projects/dex-os
- http://ics.uplb.edu.ph
- http://jachermocilla.org

Thank you!
Questions?