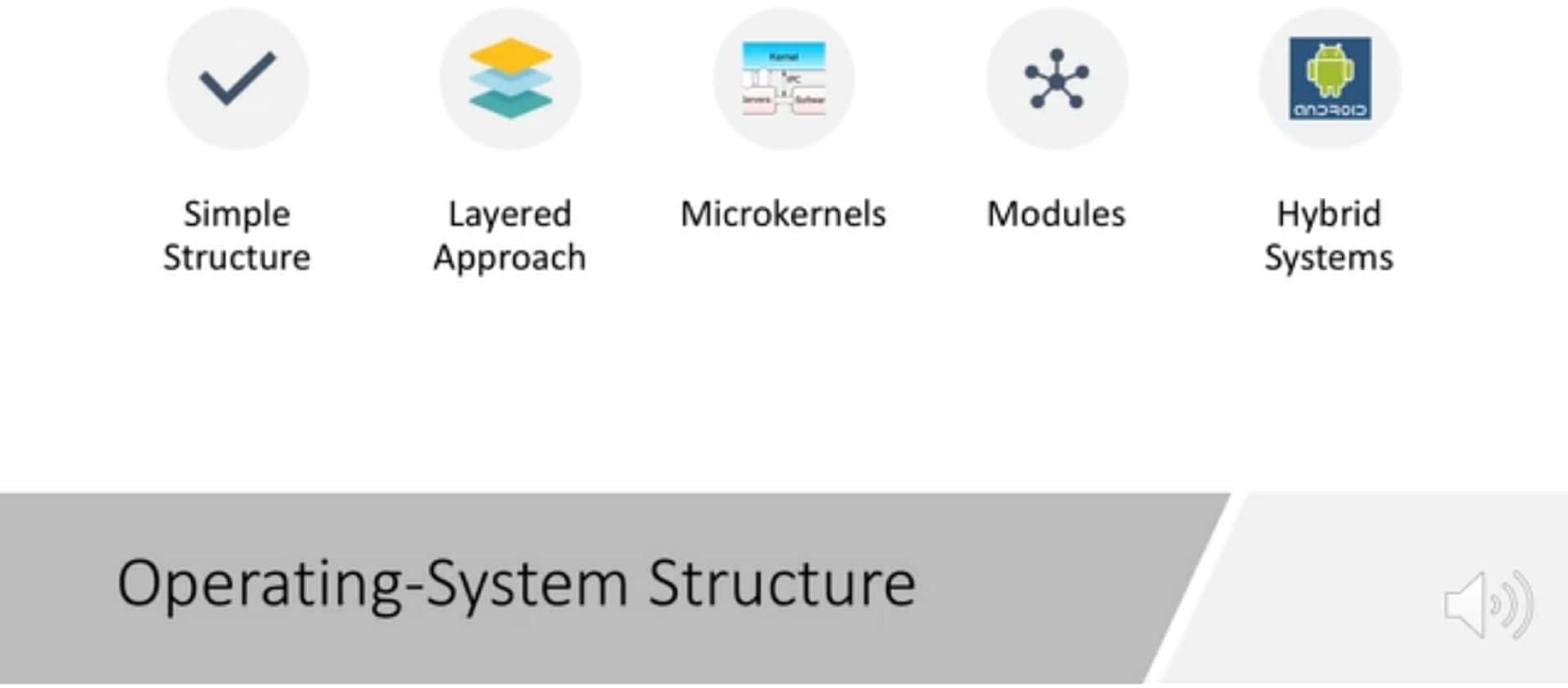

- Simple Structure
- Layered Approach
- Microkernels
- Modules
- Hybrid Systems

Operating-System Structure

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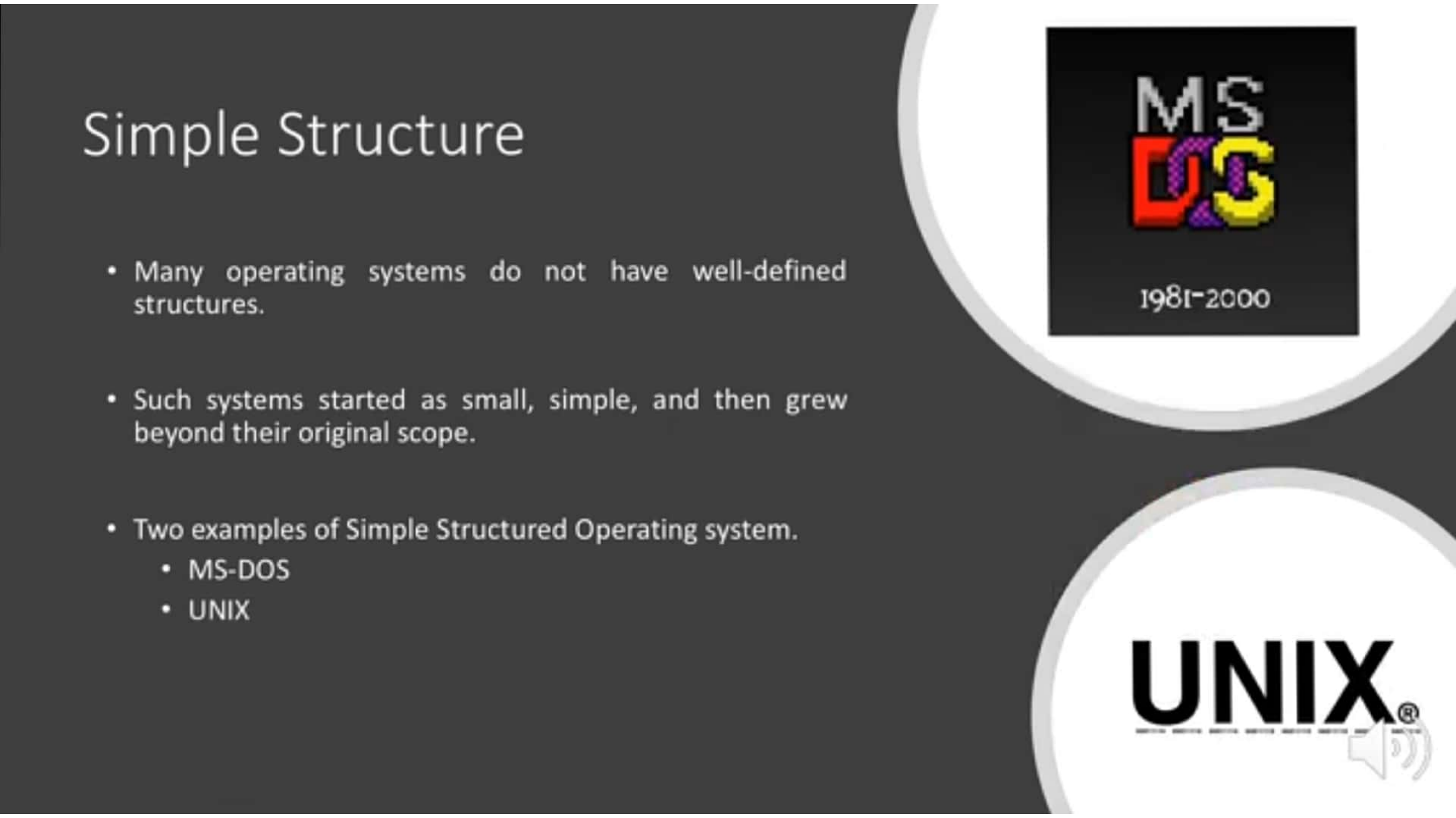

Simple Structure

- Many operating systems do not have well-defined structures.
- Such systems started as small, simple, and then grew beyond their original scope.
- Two examples of Simple Structured Operating system.
  - MS-DOS
  - UNIX

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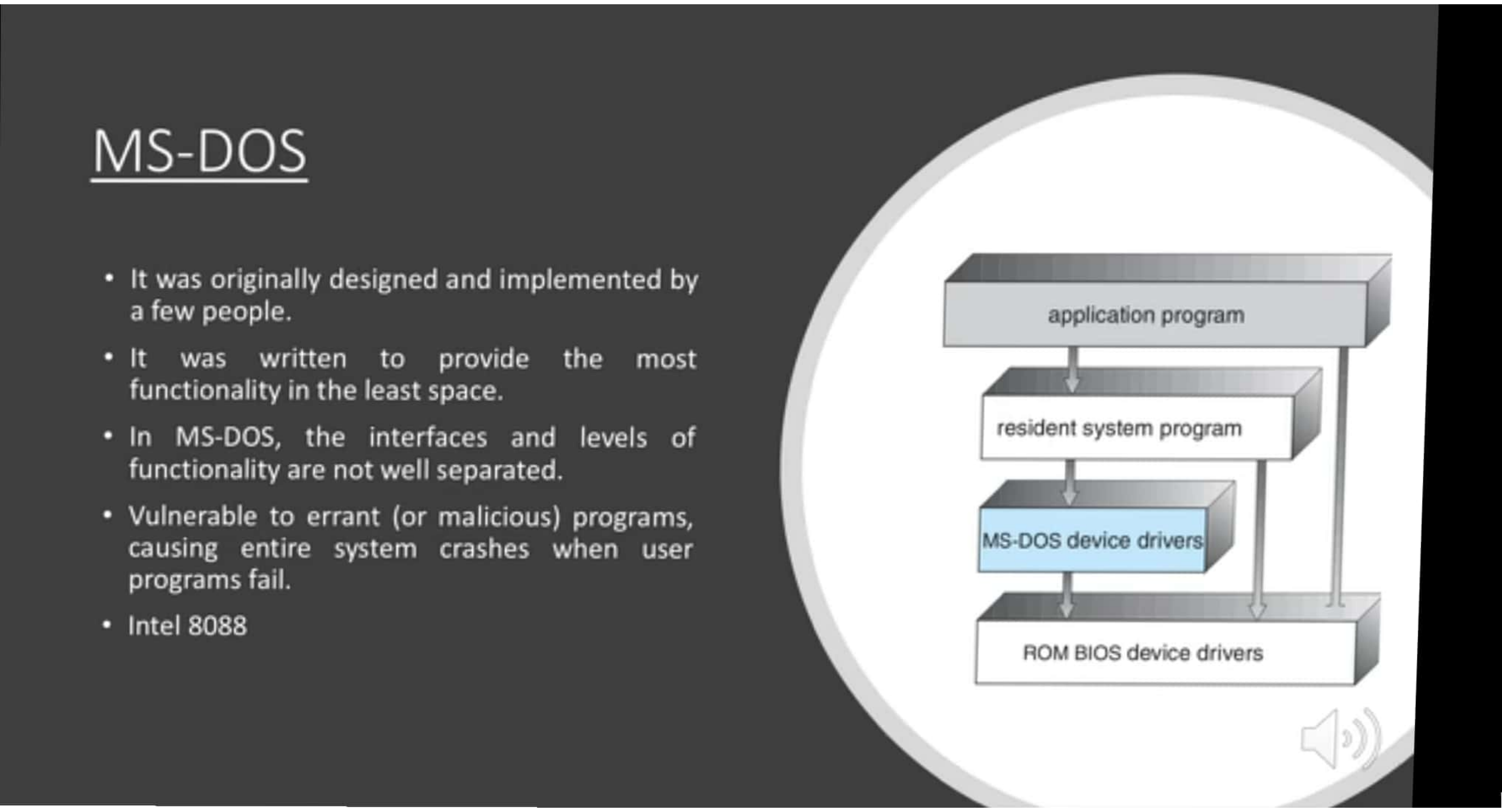

MS-DOS

- It was originally designed and implemented by a few people.
- It was written to provide the most functionality in the least space.
- In MS-DOS, the interfaces and levels of functionality are not well separated.
- Vulnerable to errant (or malicious) programs, causing entire system crashes when user programs fail.
- Intel 8088

application program

resident system program

MS-DOS device drivers

ROM BIOS device drivers

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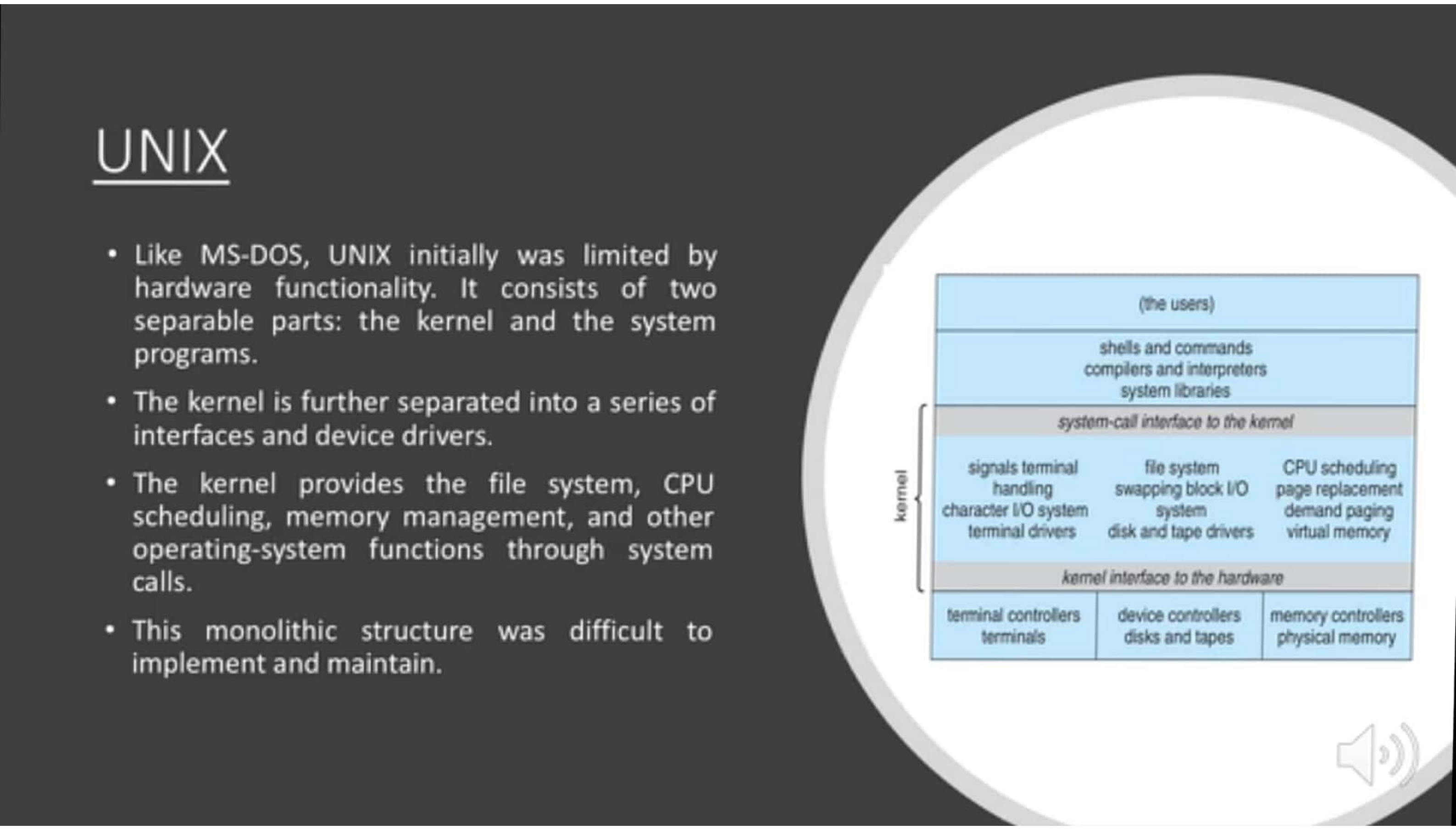

UNIX

- Like MS-DOS, UNIX initially was limited by hardware functionality. It consists of two separable parts: the kernel and the system programs.
- The kernel is further separated into a series of interfaces and device drivers.
- The kernel provides the file system, CPU scheduling, memory management, and other operating-system functions through system calls.
- This monolithic structure was difficult to implement and maintain.

kernel

(the users)		
shells and commands compilers and interpreters system libraries		
system-call interface to the kernel		
signals terminal handling character I/O system terminal drivers	file system swapping block I/O system disk and tape drivers	CPU scheduling page replacement demand paging virtual memory
kernel interface to the hardware		
terminal controllers terminals	device controllers disks and tapes	memory controllers physical memory

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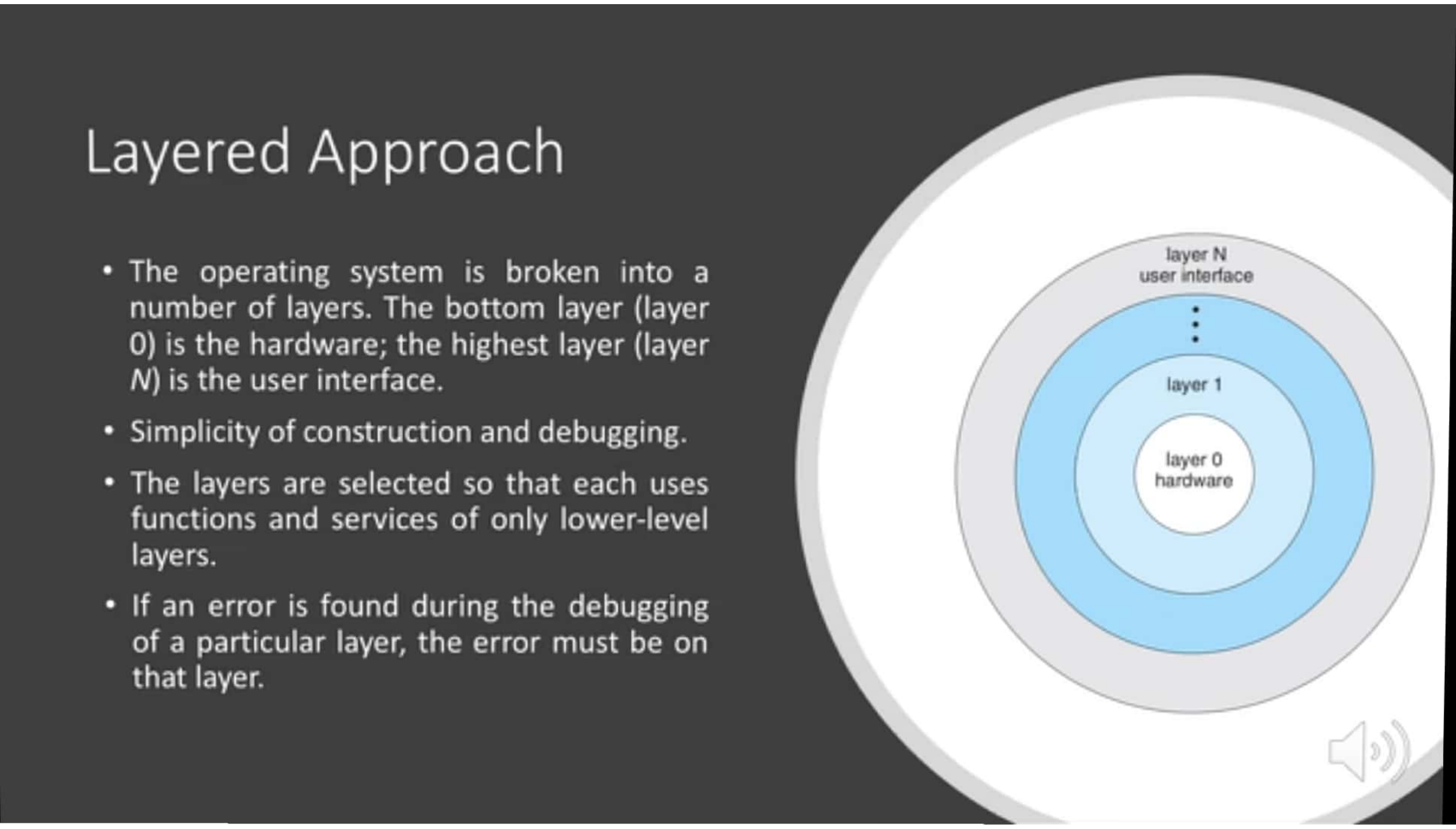

Layered Approach

- The operating system is broken into a number of layers. The bottom layer (layer 0) is the hardware; the highest layer (layer *N*) is the user interface.
- Simplicity of construction and debugging.
- The layers are selected so that each uses functions and services of only lower-level layers.
- If an error is found during the debugging of a particular layer, the error must be on that layer.

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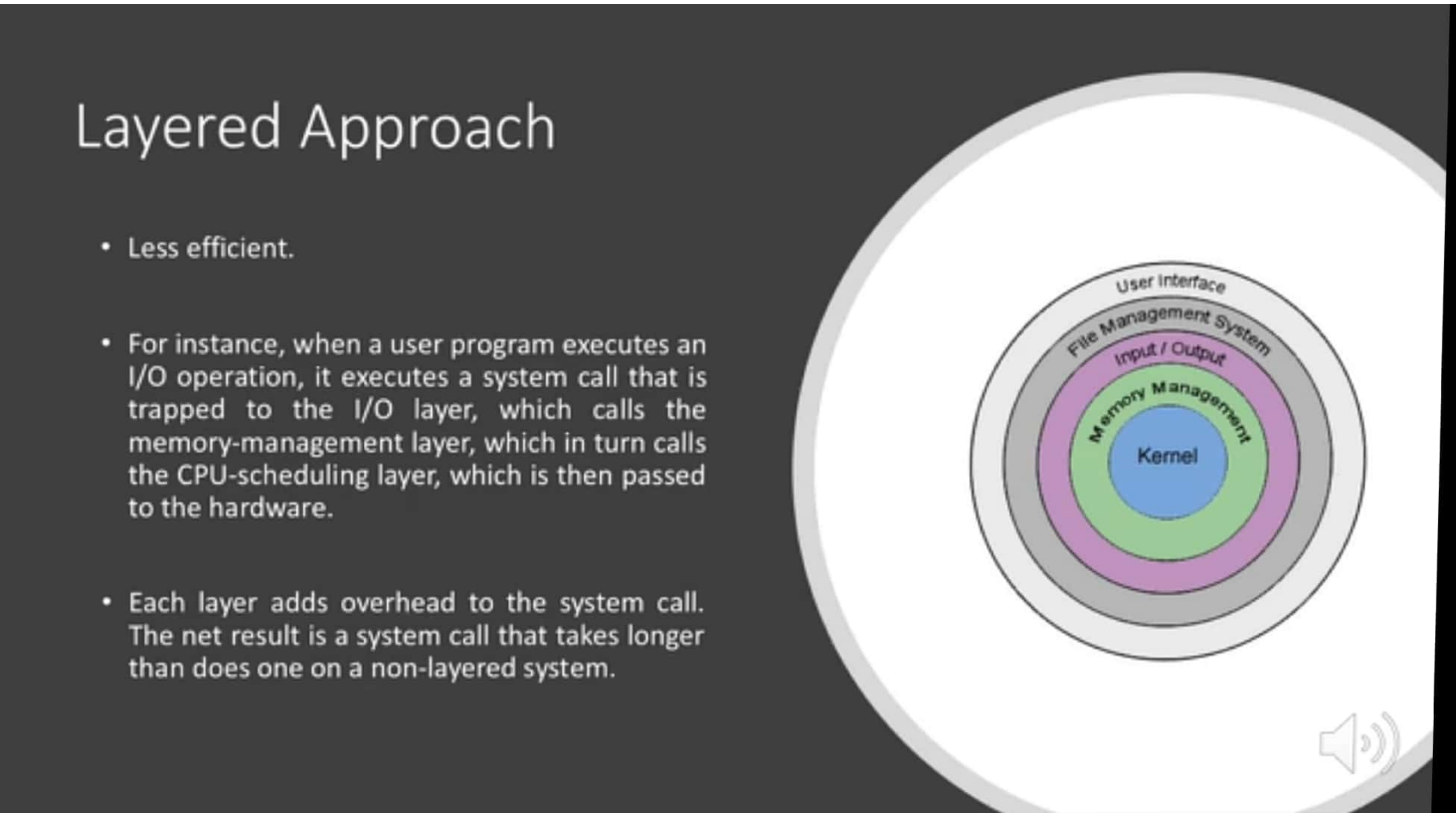

Layered Approach

- Less efficient.
- For instance, when a user program executes an I/O operation, it executes a system call that is trapped to the I/O layer, which calls the memory-management layer, which in turn calls the CPU-scheduling layer, which is then passed to the hardware.
- Each layer adds overhead to the system call. The net result is a system call that takes longer than does one on a non-layered system.

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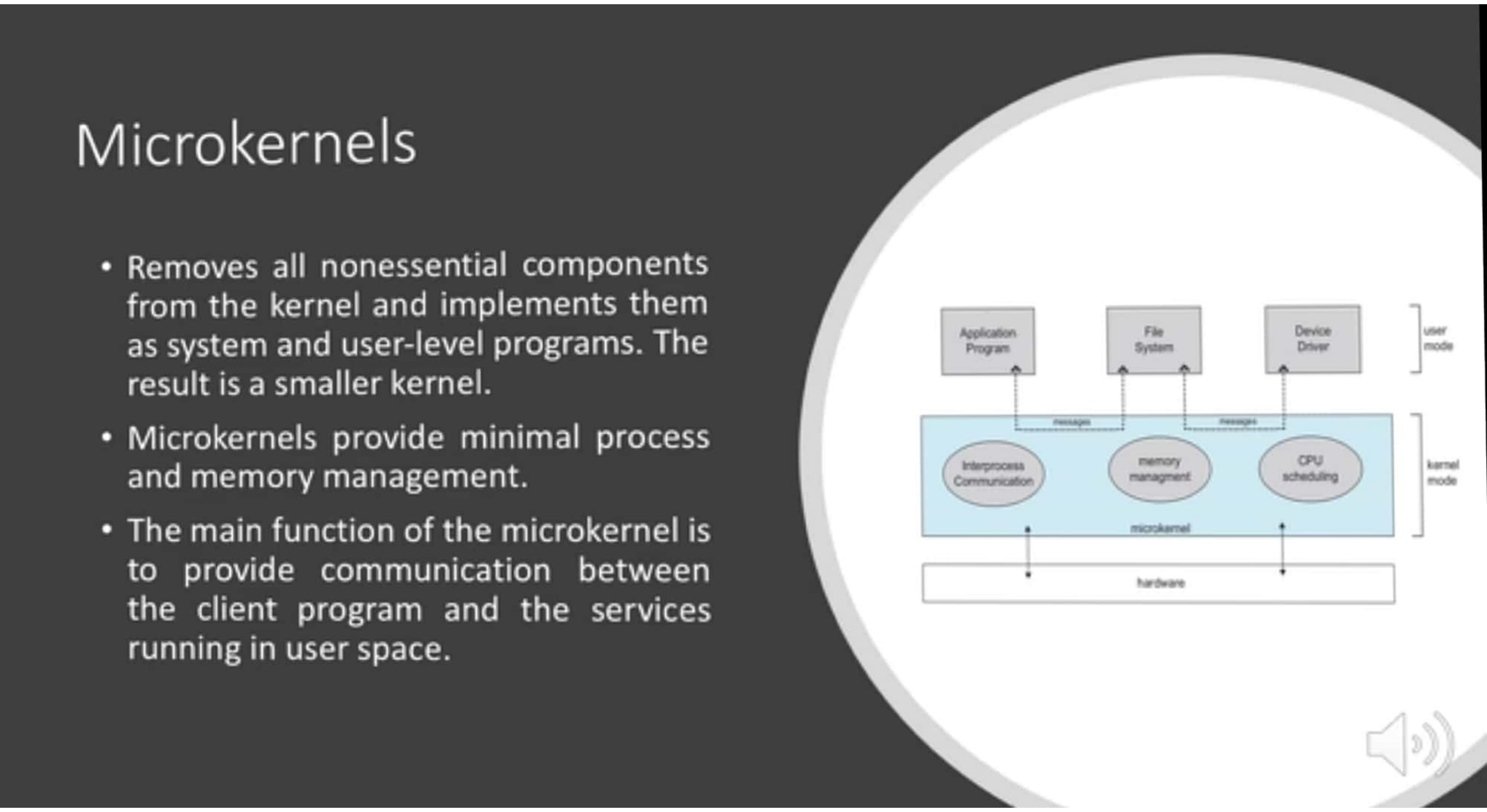

Microkernels

- Removes all nonessential components from the kernel and implements them as system and user-level programs. The result is a smaller kernel.
- Microkernels provide minimal process and memory management.
- The main function of the microkernel is to provide communication between the client program and the services running in user space.

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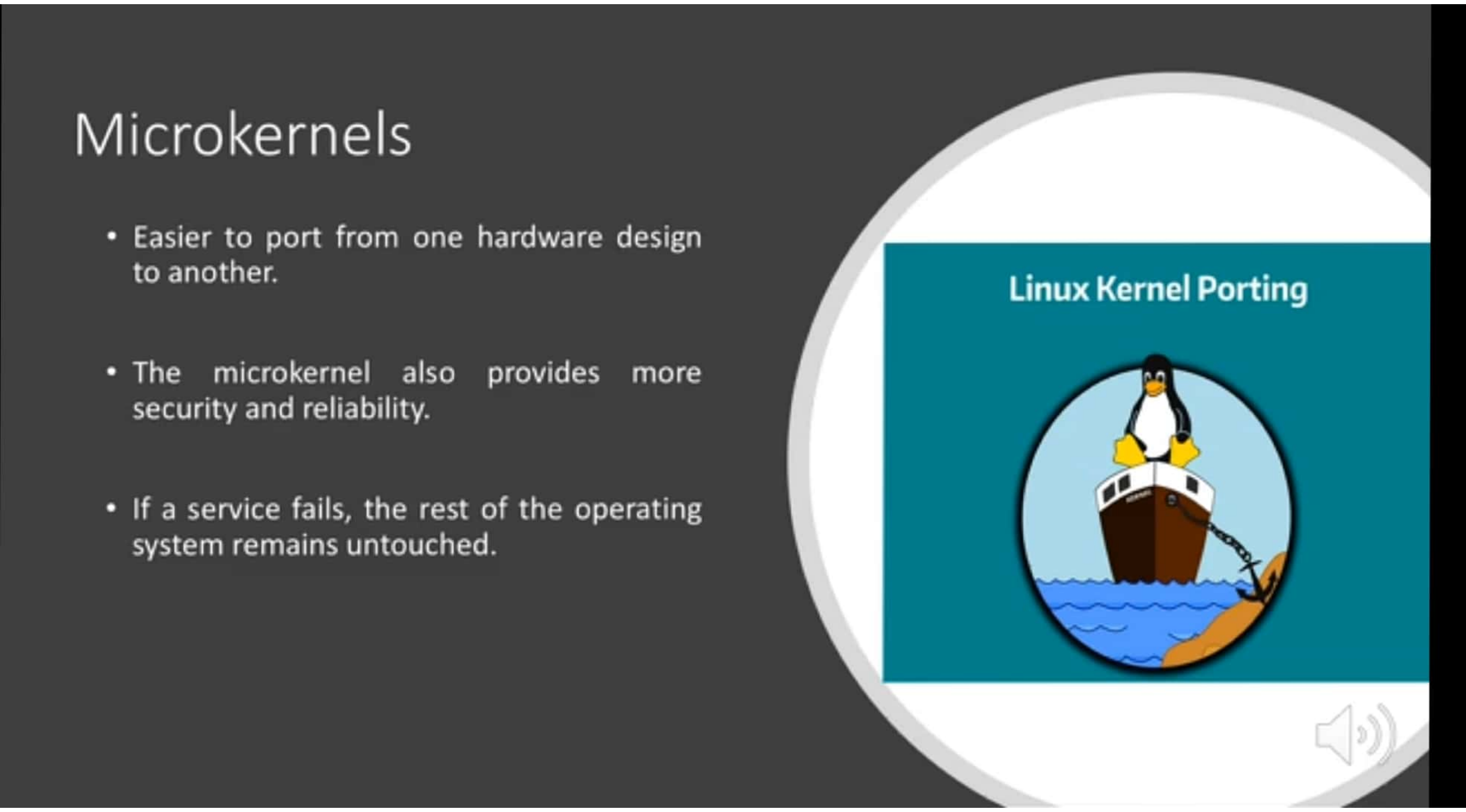

Microkernels

- Easier to port from one hardware design to another.
- The microkernel also provides more security and reliability.
- If a service fails, the rest of the operating system remains untouched.

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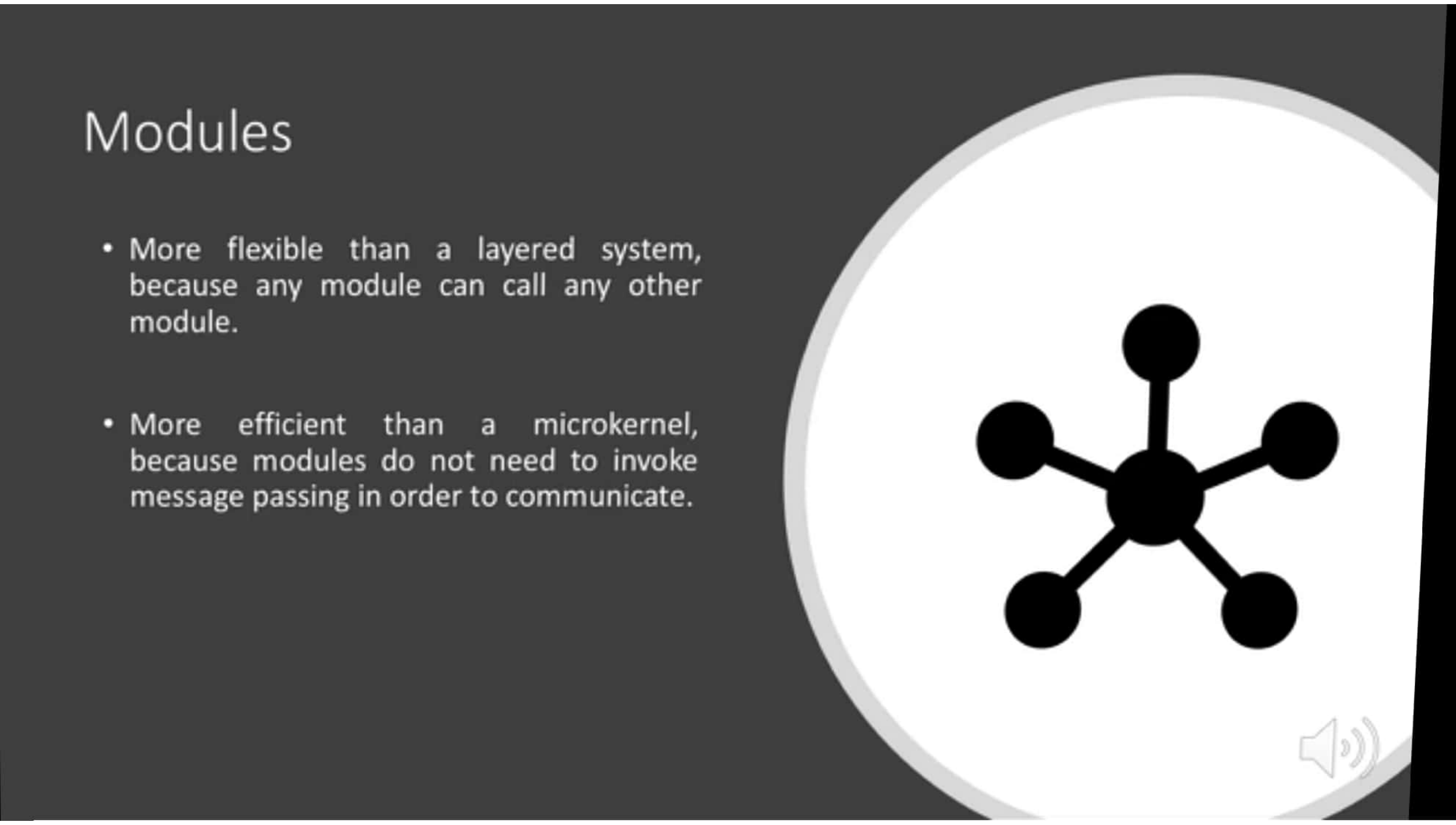

Modules

- More flexible than a layered system, because any module can call any other module.
- More efficient than a microkernel, because modules do not need to invoke message passing in order to communicate.

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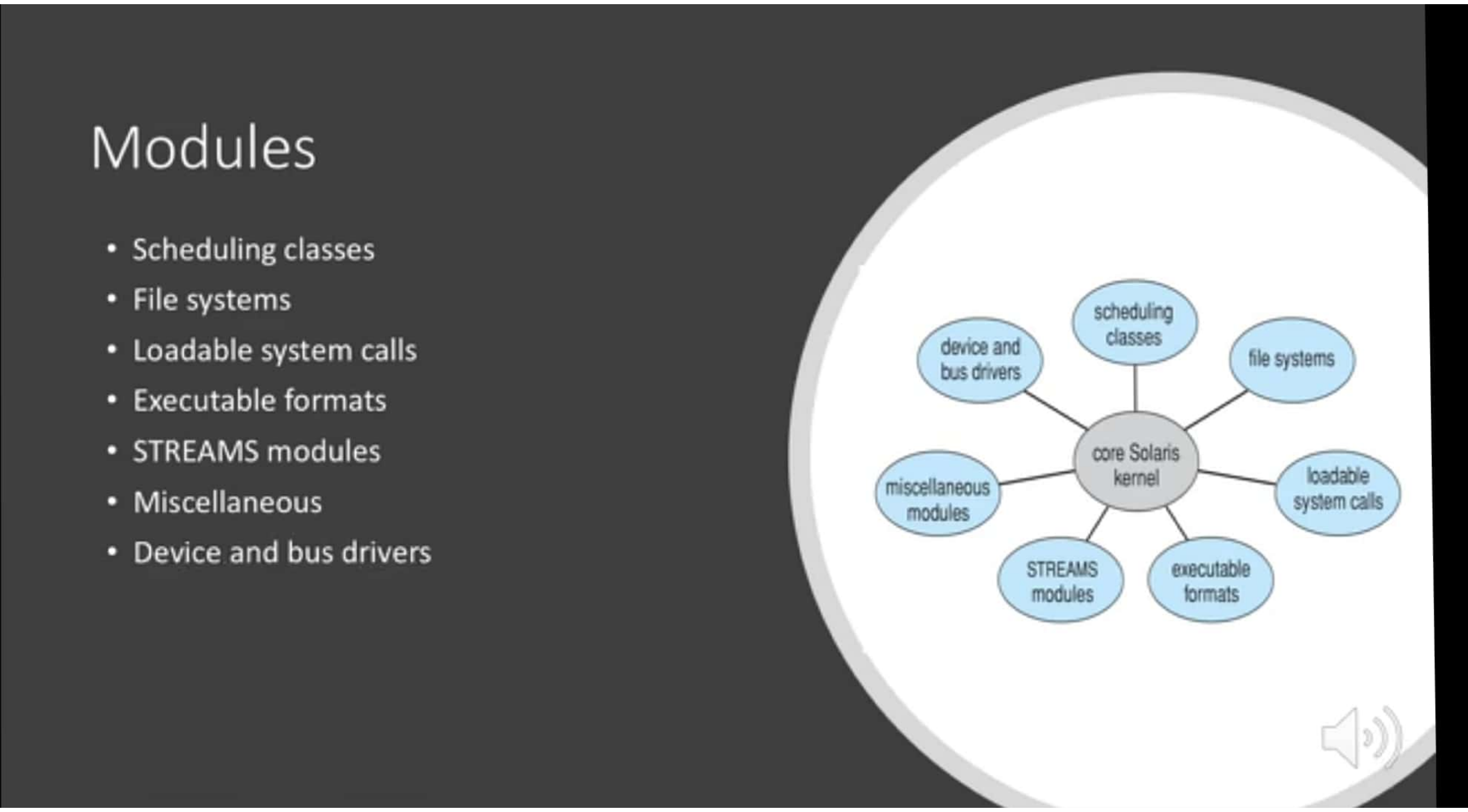

Modules

- Scheduling classes
- File systems
- Loadable system calls
- Executable formats
- STREAMS modules
- Miscellaneous
- Device and bus drivers

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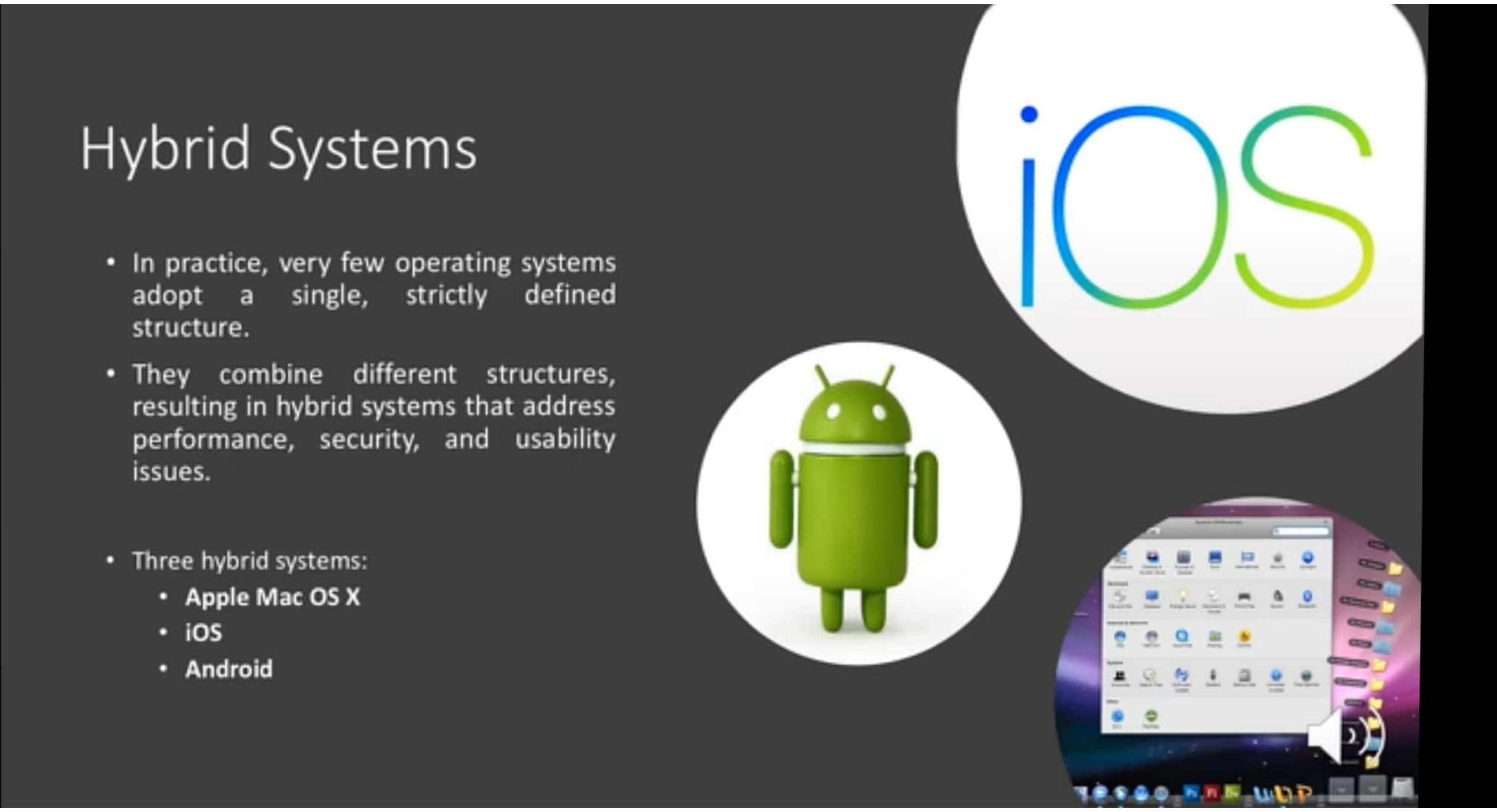

Hybrid Systems

- In practice, very few operating systems adopt a single, strictly defined structure.
- They combine different structures, resulting in hybrid systems that address performance, security, and usability issues.
- Three hybrid systems:
  - **Apple Mac OS X**
  - **iOS**
  - **Android**

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