A Remote I/O Solution for the Cloud

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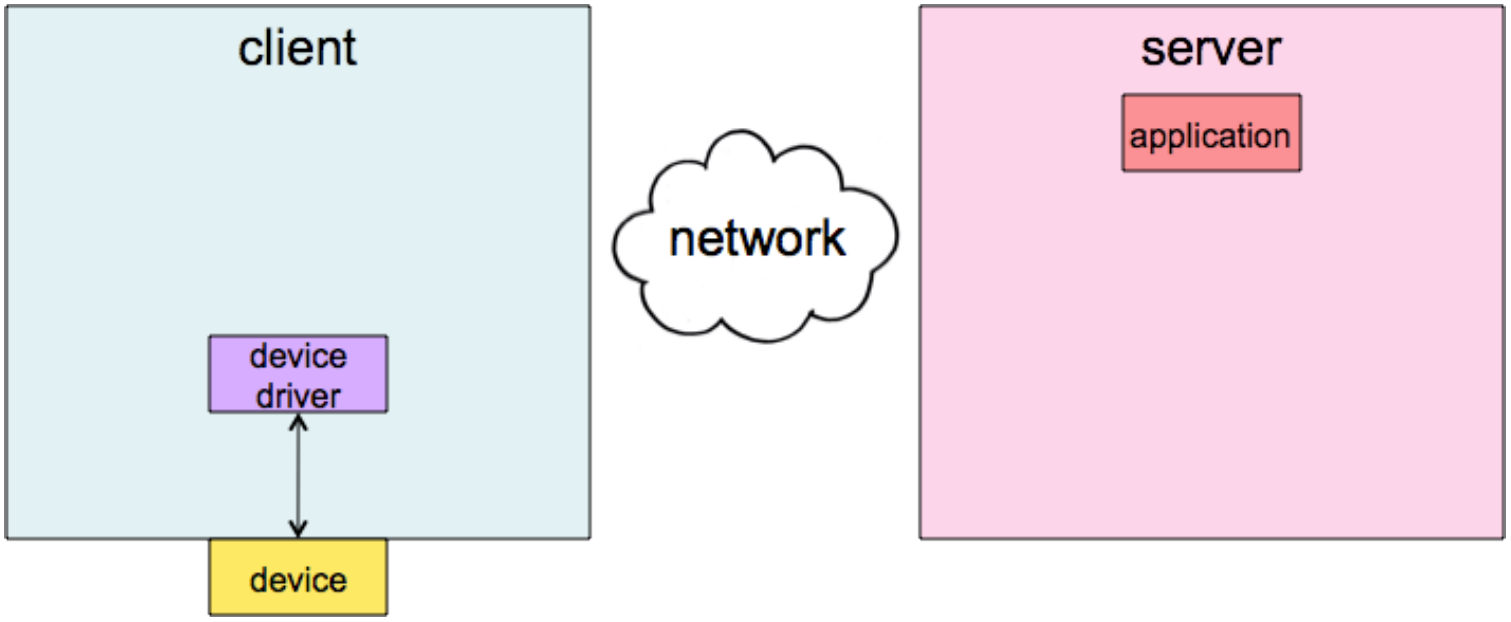
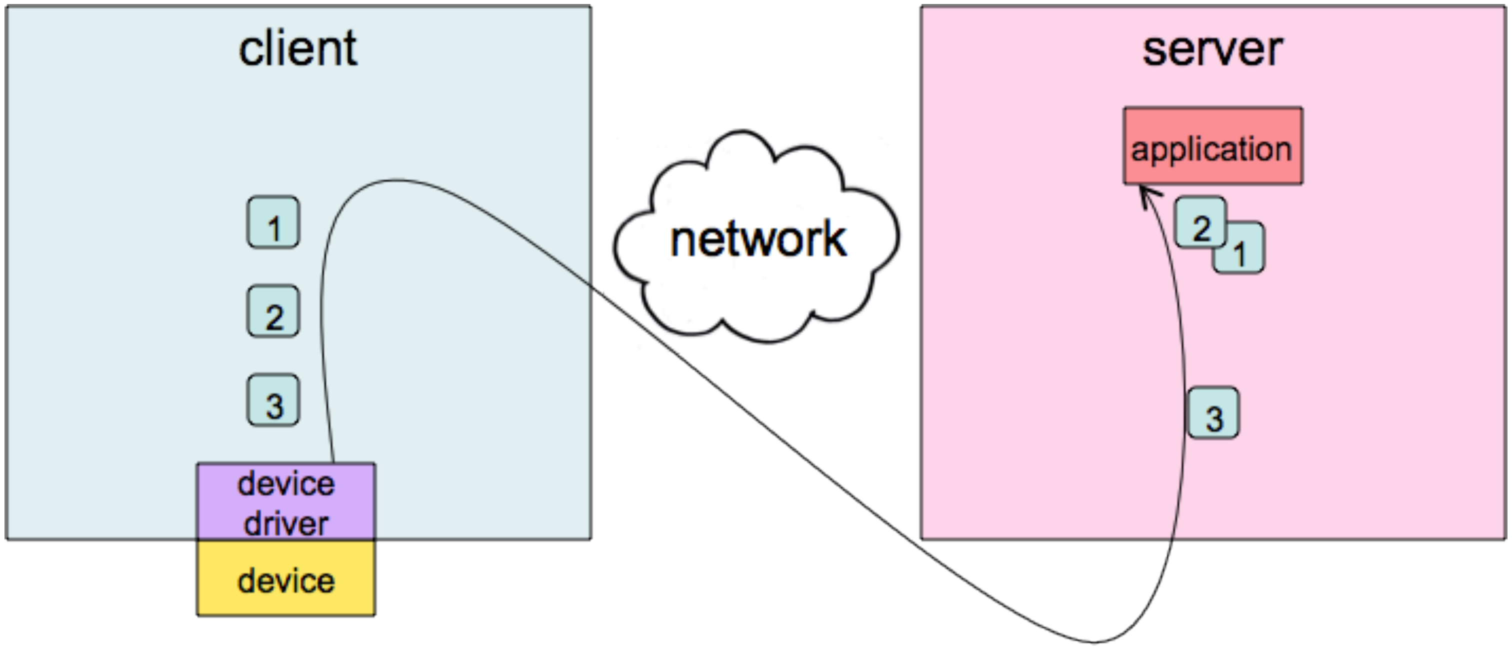
Motivation

Why Remote I/O?

Transparency



Transformation



No Single Solution

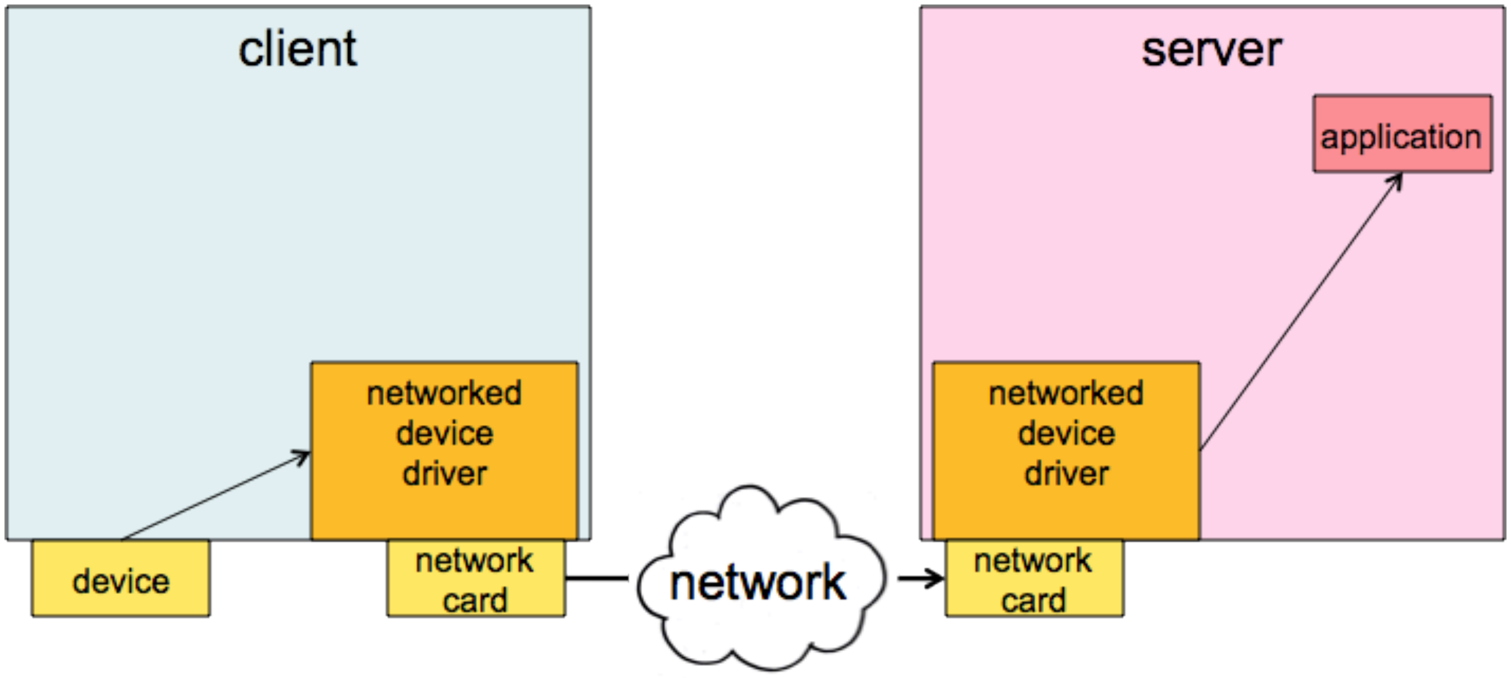
- Different devices
- Different applications
- Different network conditions
- Different optimal solutions

Architecture

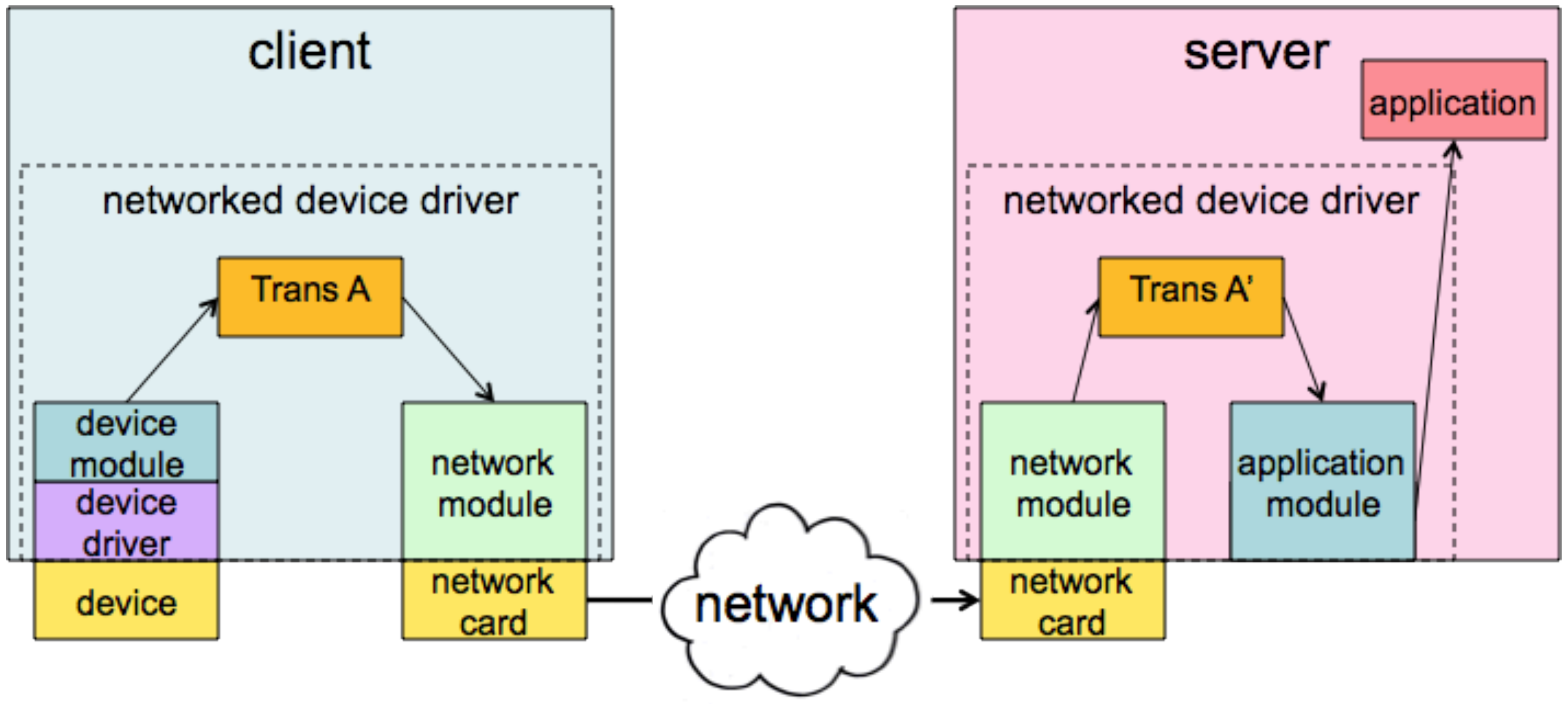
Diverse Beneficiaries Require Easy Customization and Extensibility

- Device designers
- Application designers
- Users

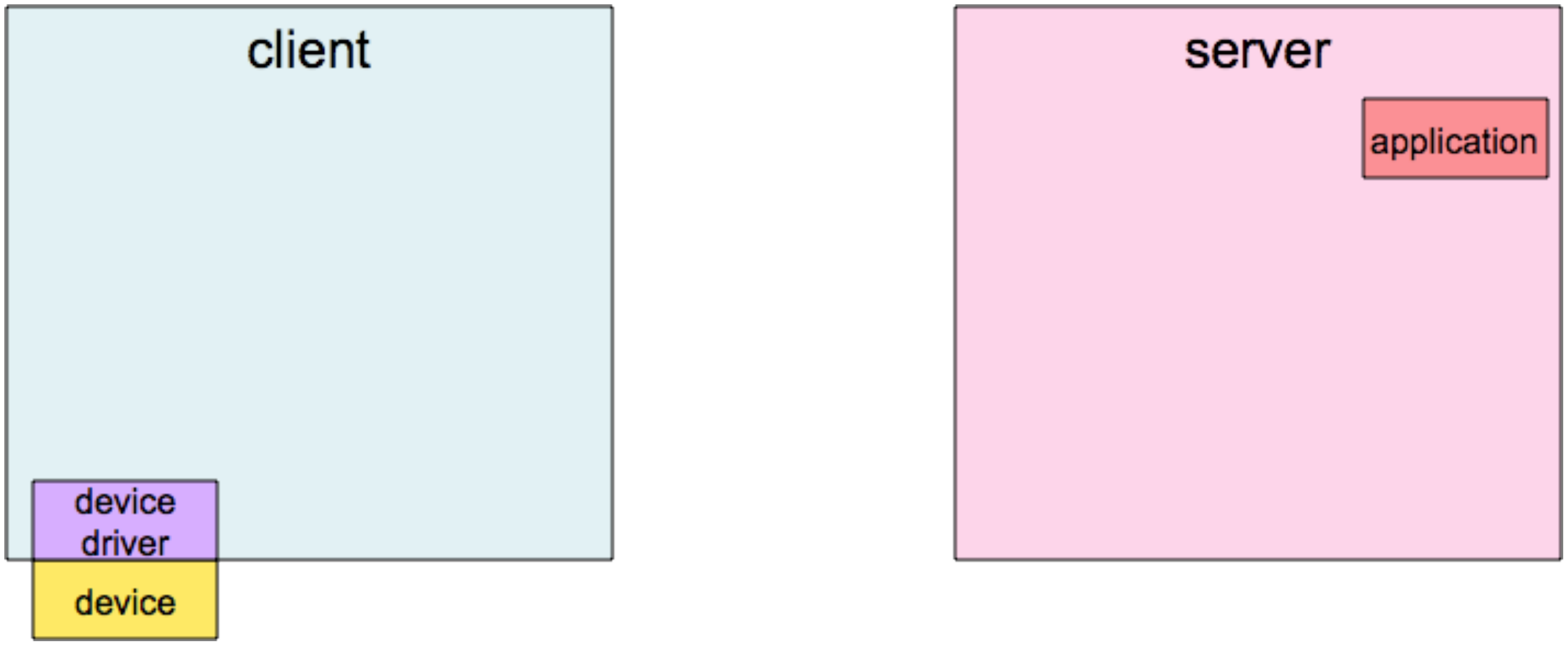
Networked Device Driver Abstraction for Transparency



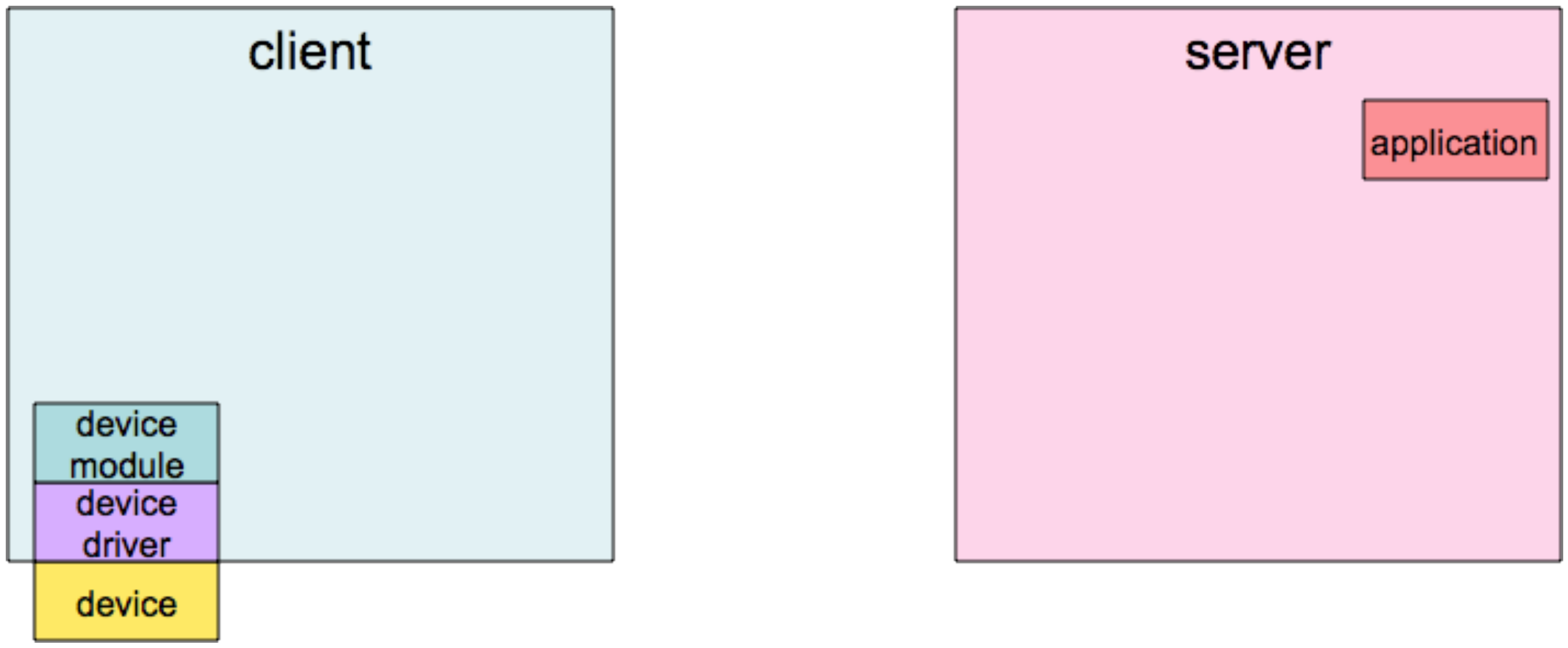
Modular Architecture



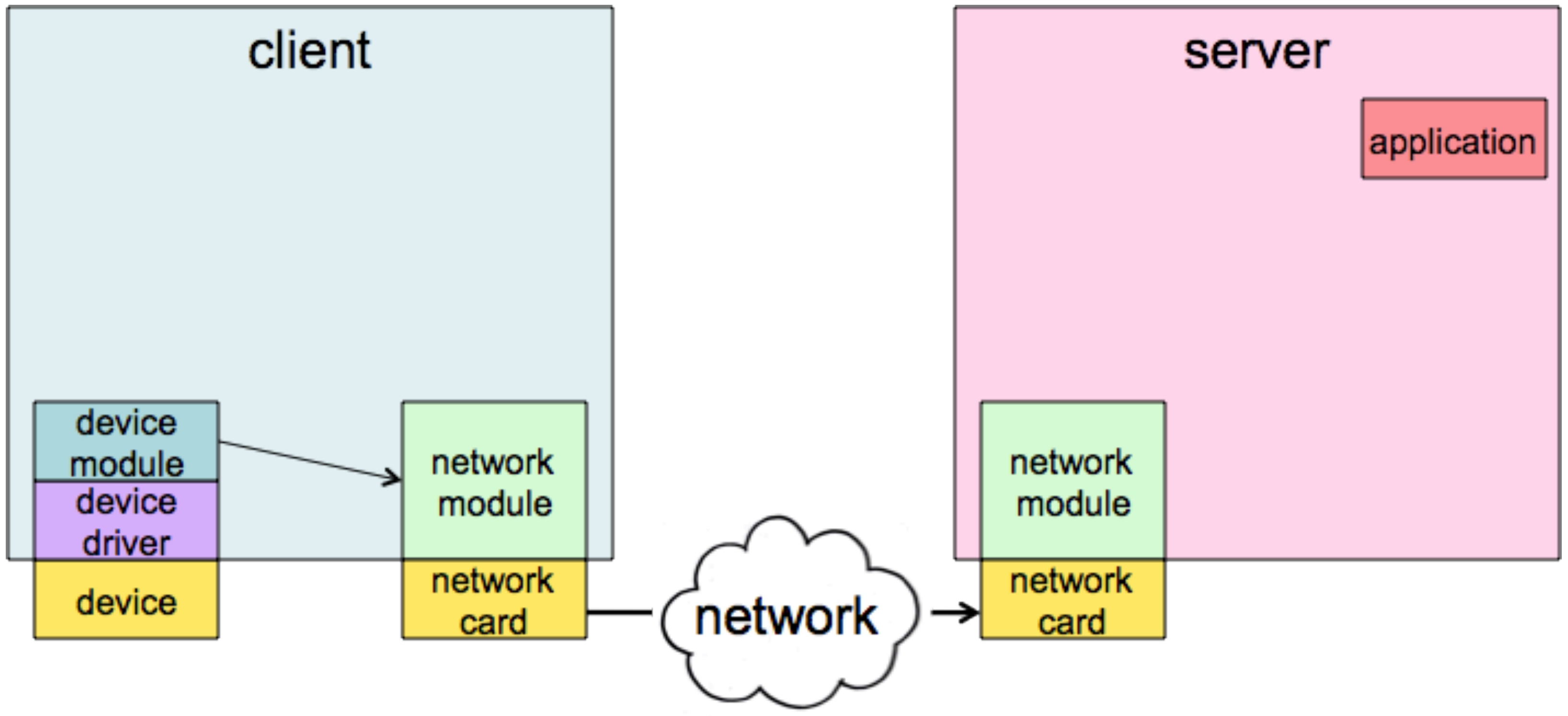
Need to Connect Device and Application



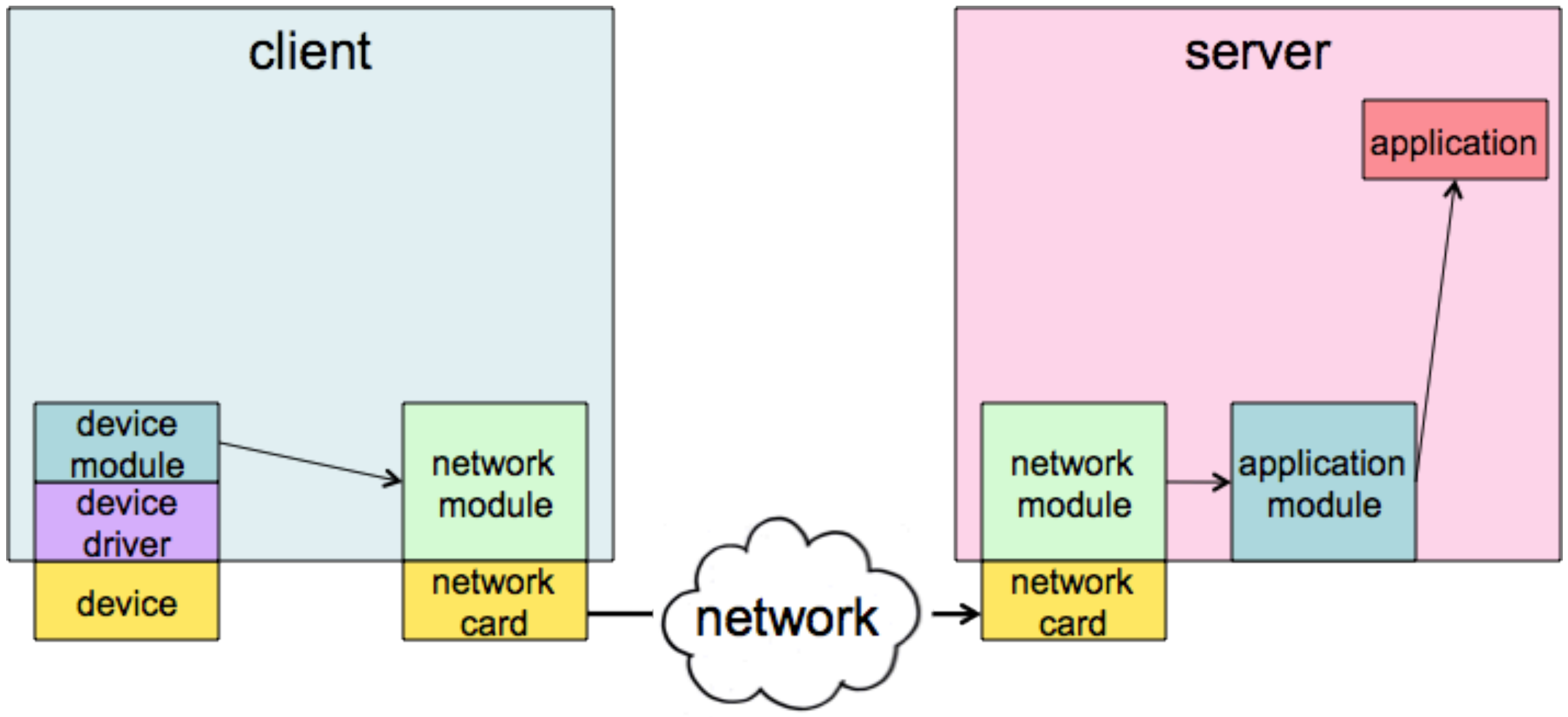
Device Module



Network Modules



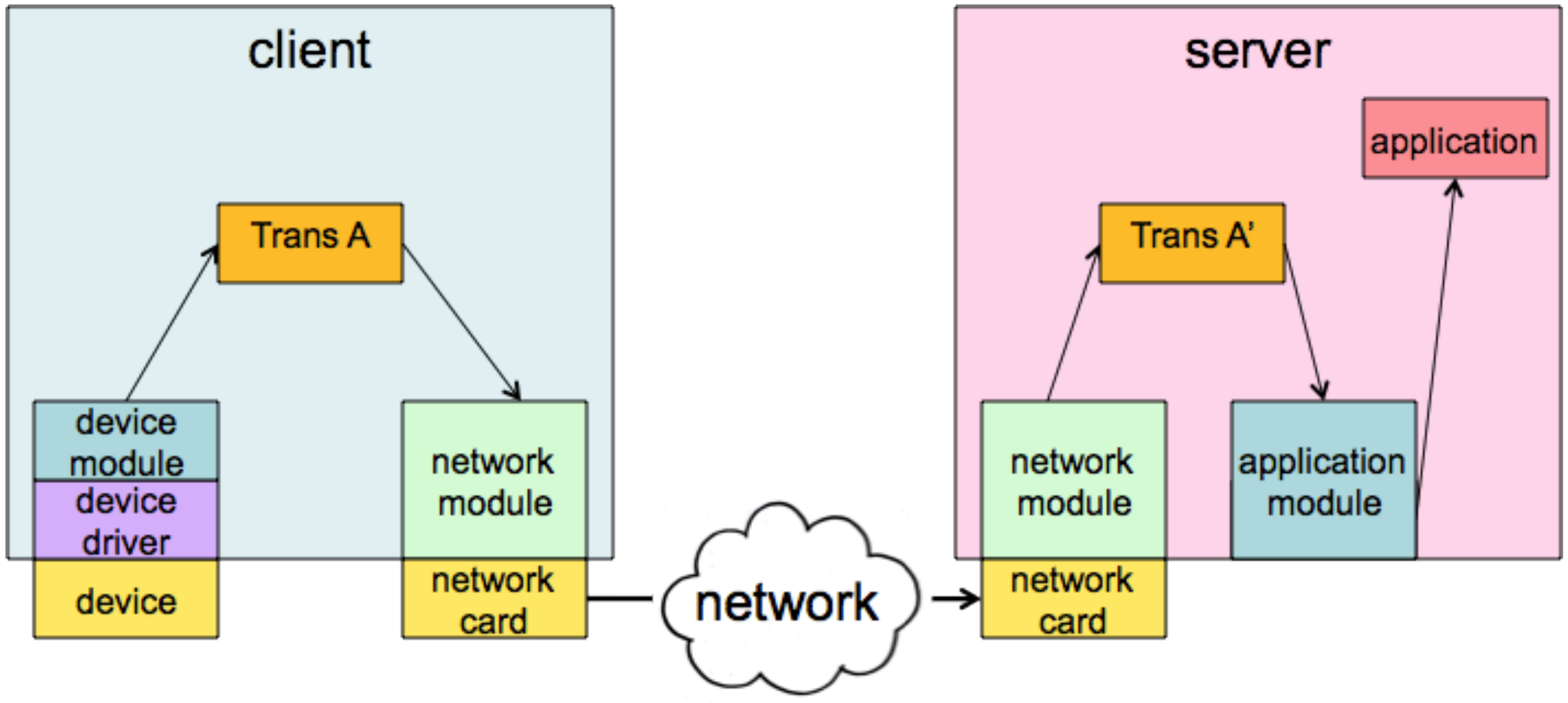
Application Module



Need to Add Data Processing for Network

- Averaging
- Bundling
- Buffering
- Compressing
- Discarding
- Encrypting
- Multiplexing
- Synchronizing

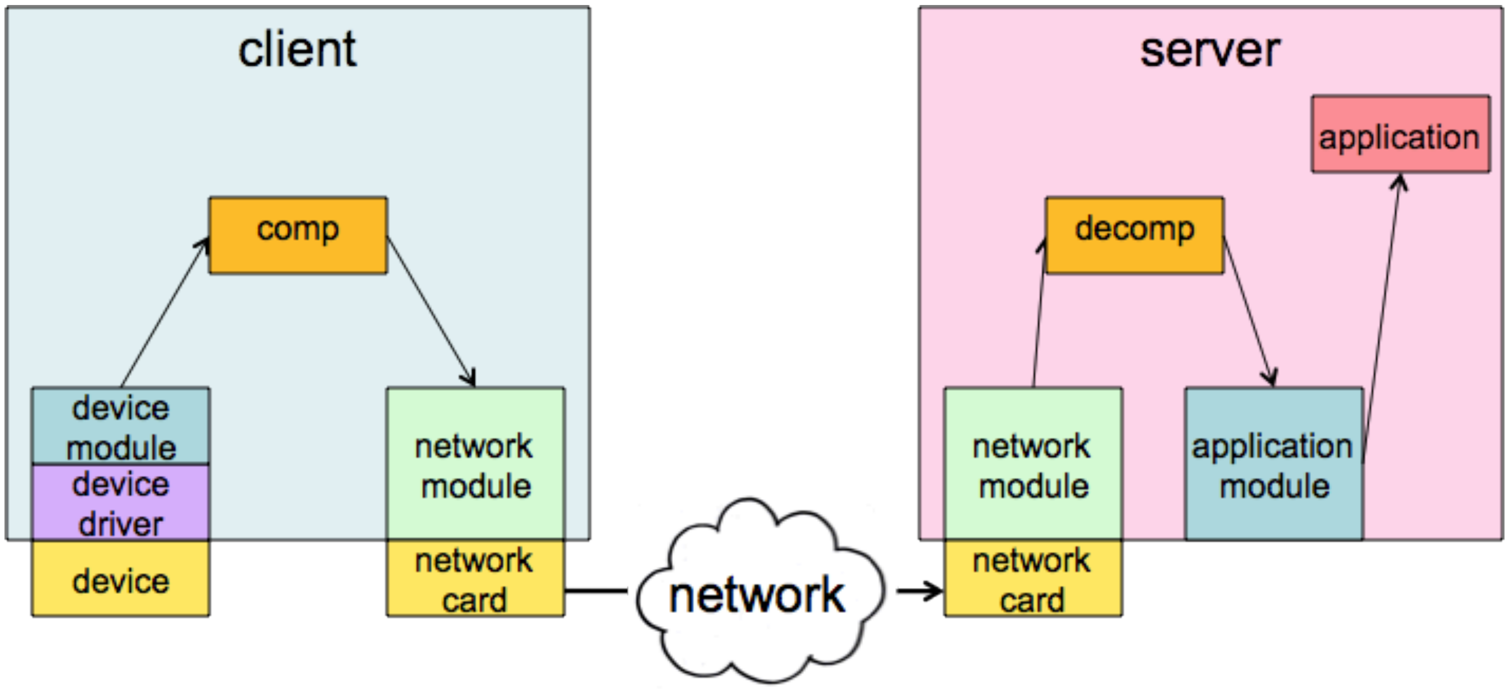
Transformation Module Pairs



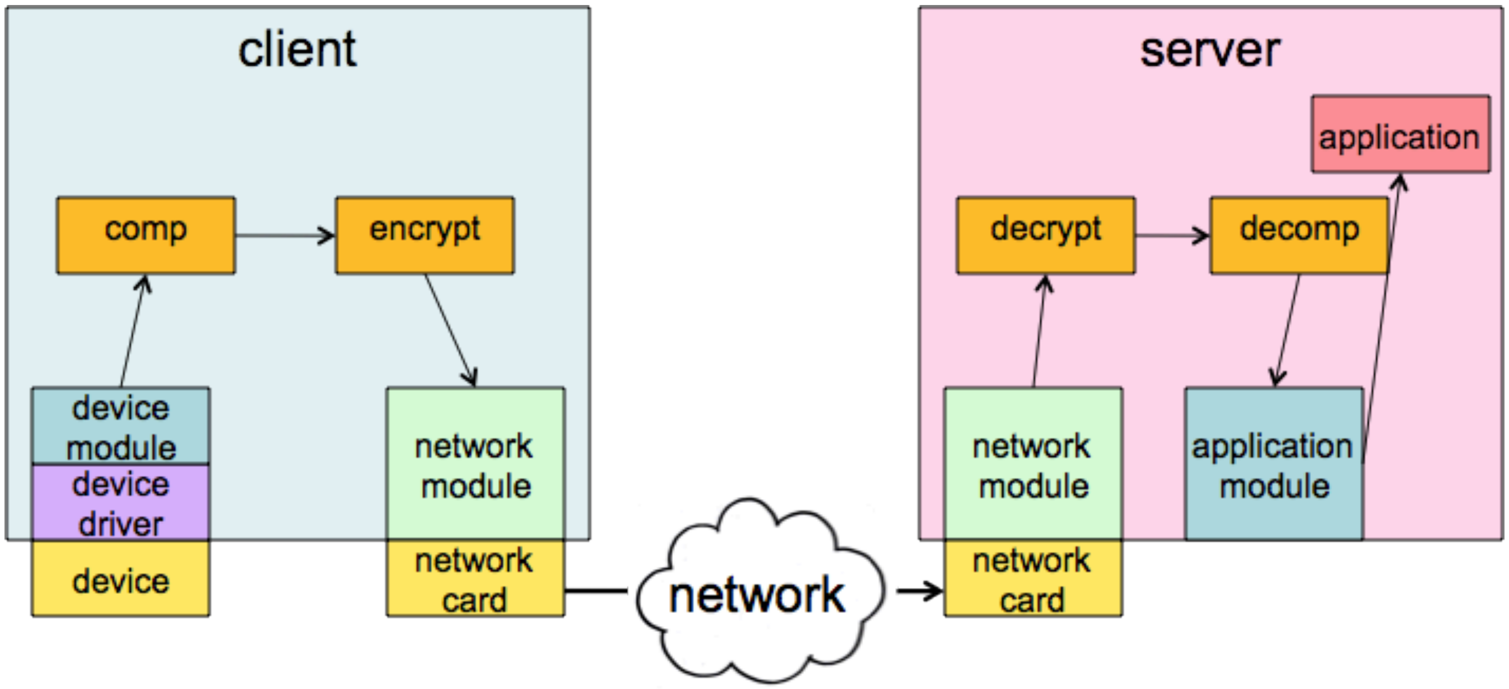
Example Module Pairs

- Compression/Decompression
- Bundling/Unbundling
- Encryption/Decryption

Compression



Composability



Summary

- Device driver abstraction supports transparency
- Modular design supports customization, extension
- Transformation module pairs allow processing of data

Implementation

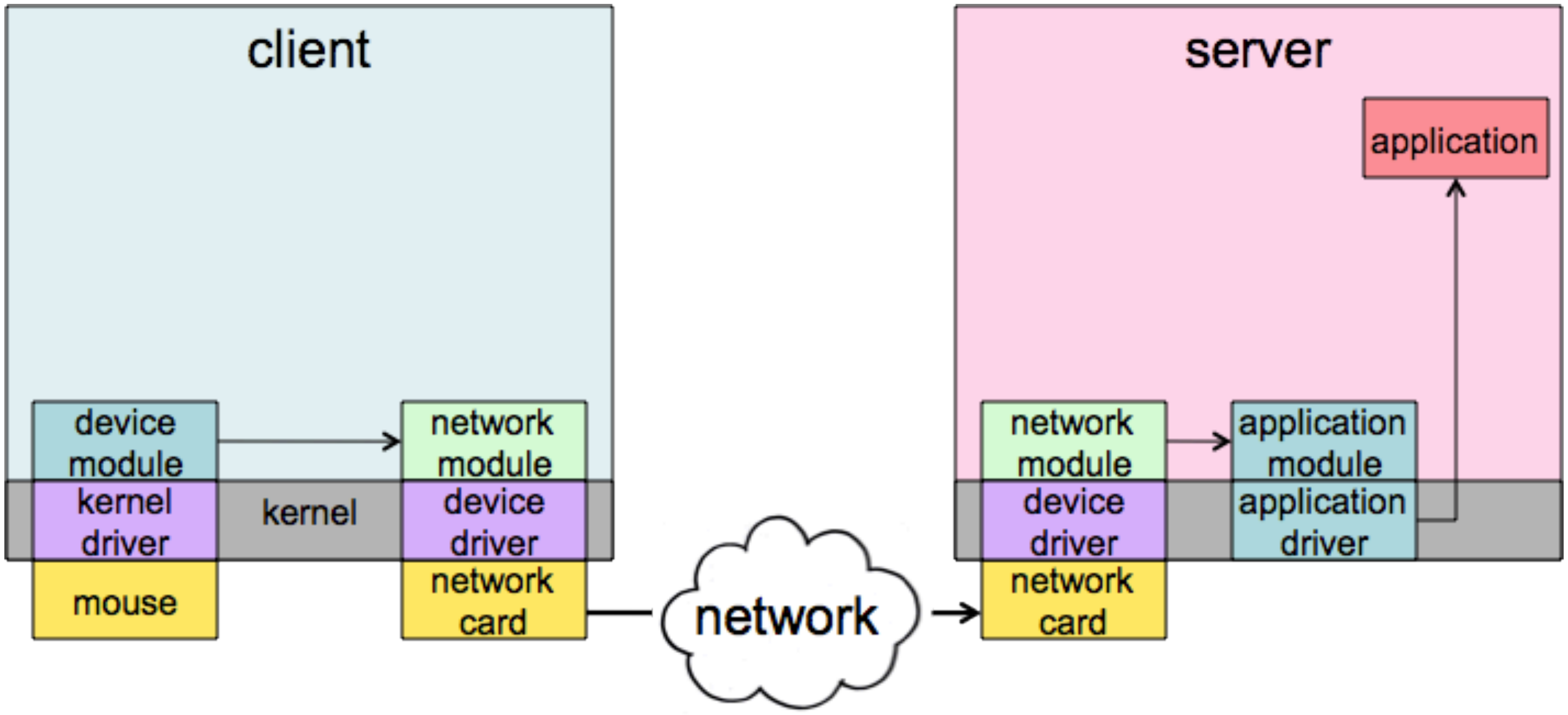
Implementation Goals

- Efficiency
- Ease of implementation
- Leveraging existing mechanisms

Kernel vs user space

- Insecure/buggy code is dangerous to run in kernel
- Allows developers to use any existing tools/libraries
- Copies between process boundaries must go through kernel

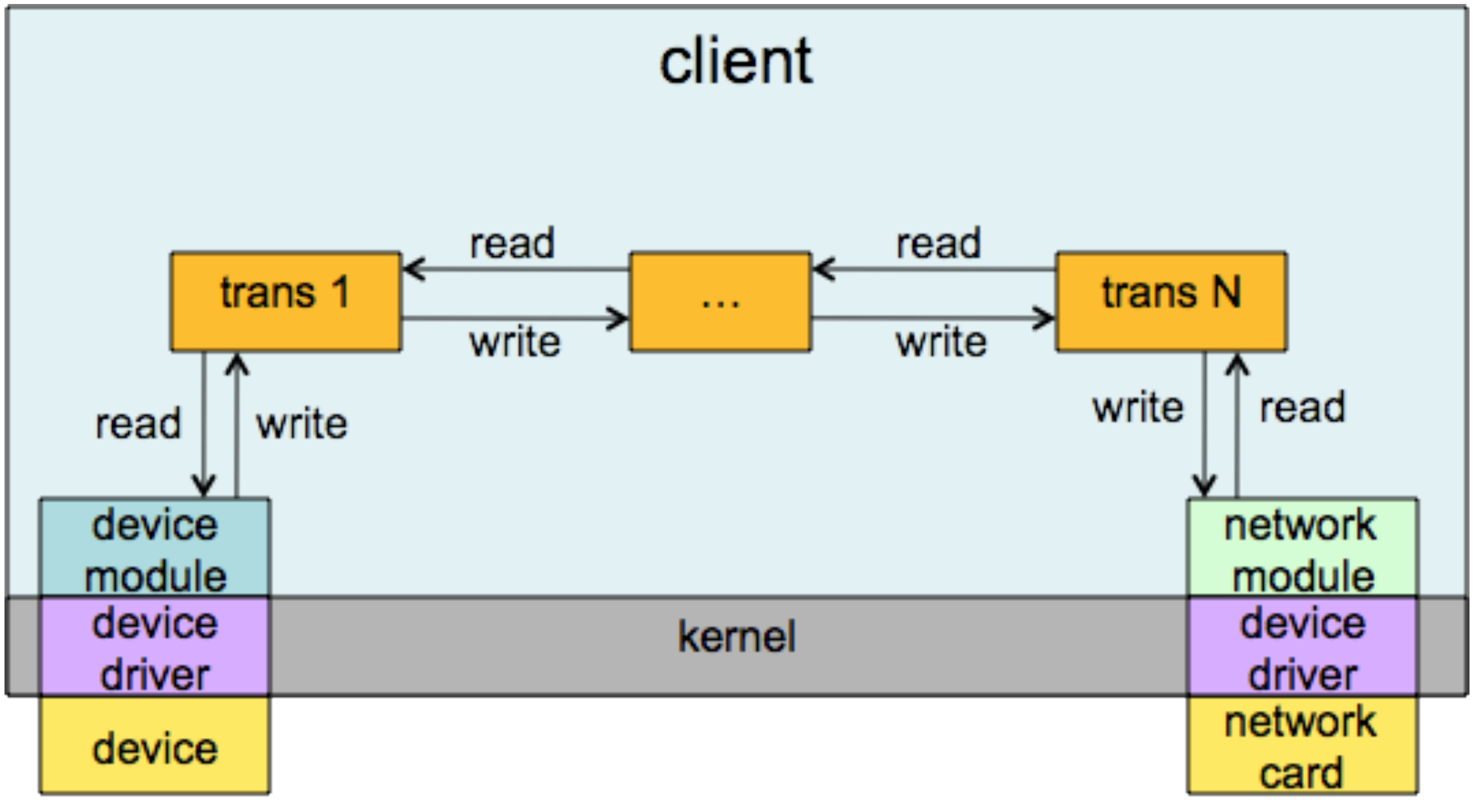
Run Predominately in Userspace to Support Extensibility



Modules as Processes Support Customization

- Can compose at run-time
- Scheduled by the kernel
- Automatically block on I/O
- Separate address spaces

Pipes Copy Between Processes



Implementation Summary

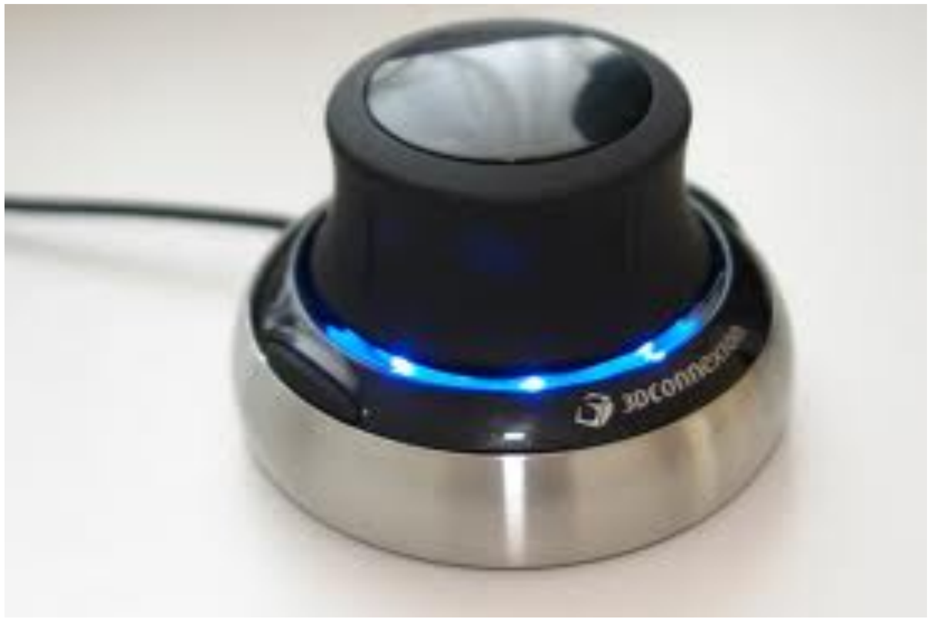
- Implemented at user-level whenever possible to support **extensibility**
- Modules are implemented as processes to support **customization**
- Pipes implementation for **ease of implementation**

Performance

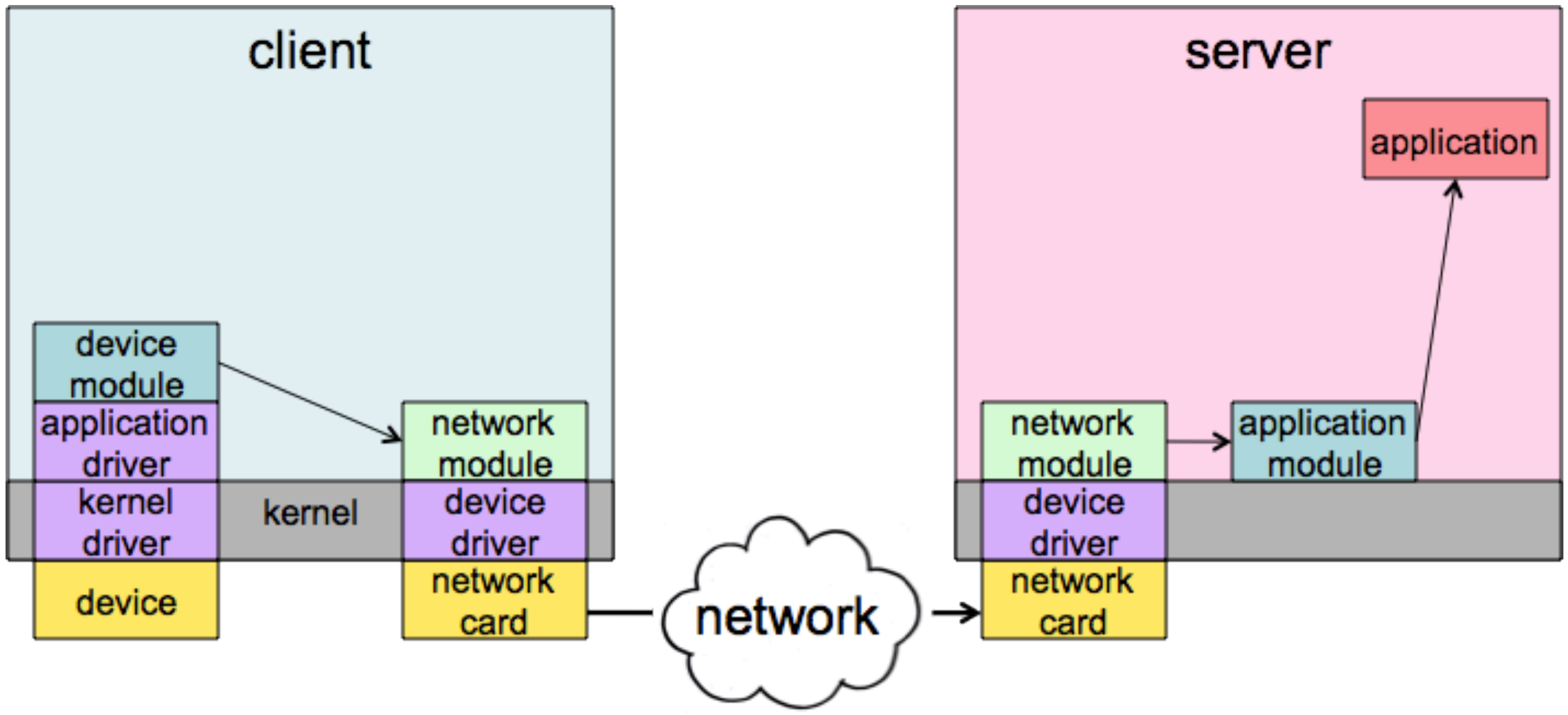
Test bed

- Dell Optiplex 320
- Intel Celeron
- 133 Mhz FSB Clock
- Ping time of .12 ms between machines
- 11.3 MB/s throughput

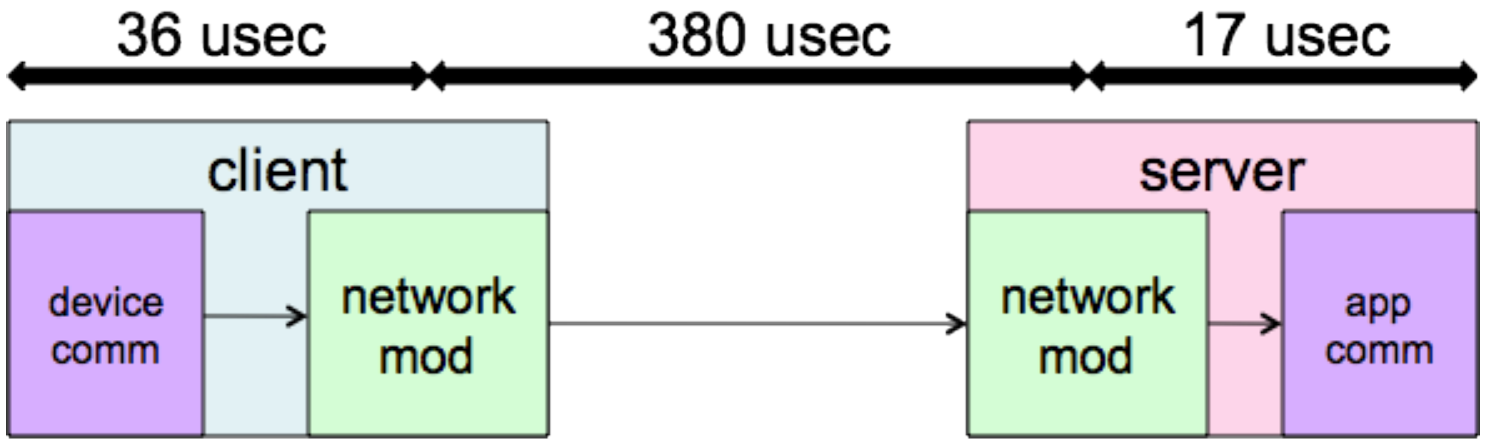
Space Navigator



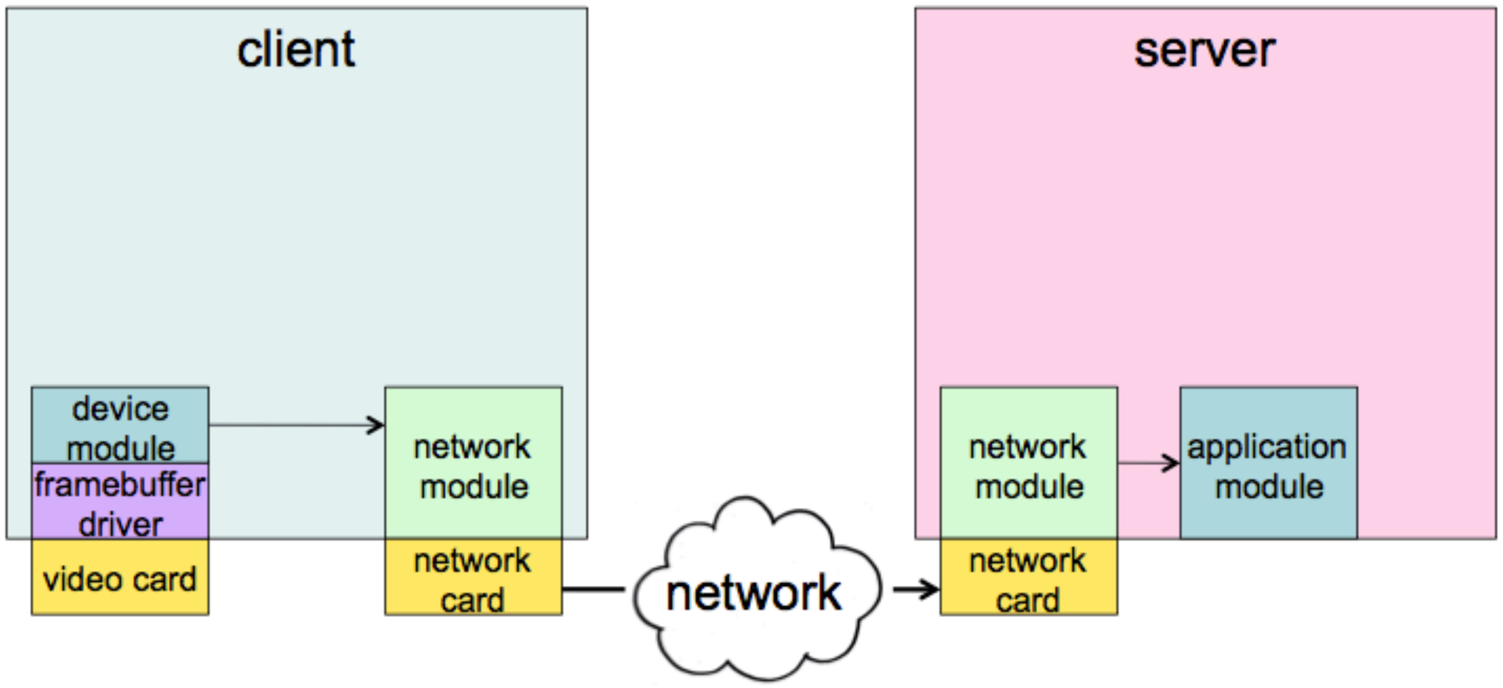
End-to-End Time of the Space Navigator



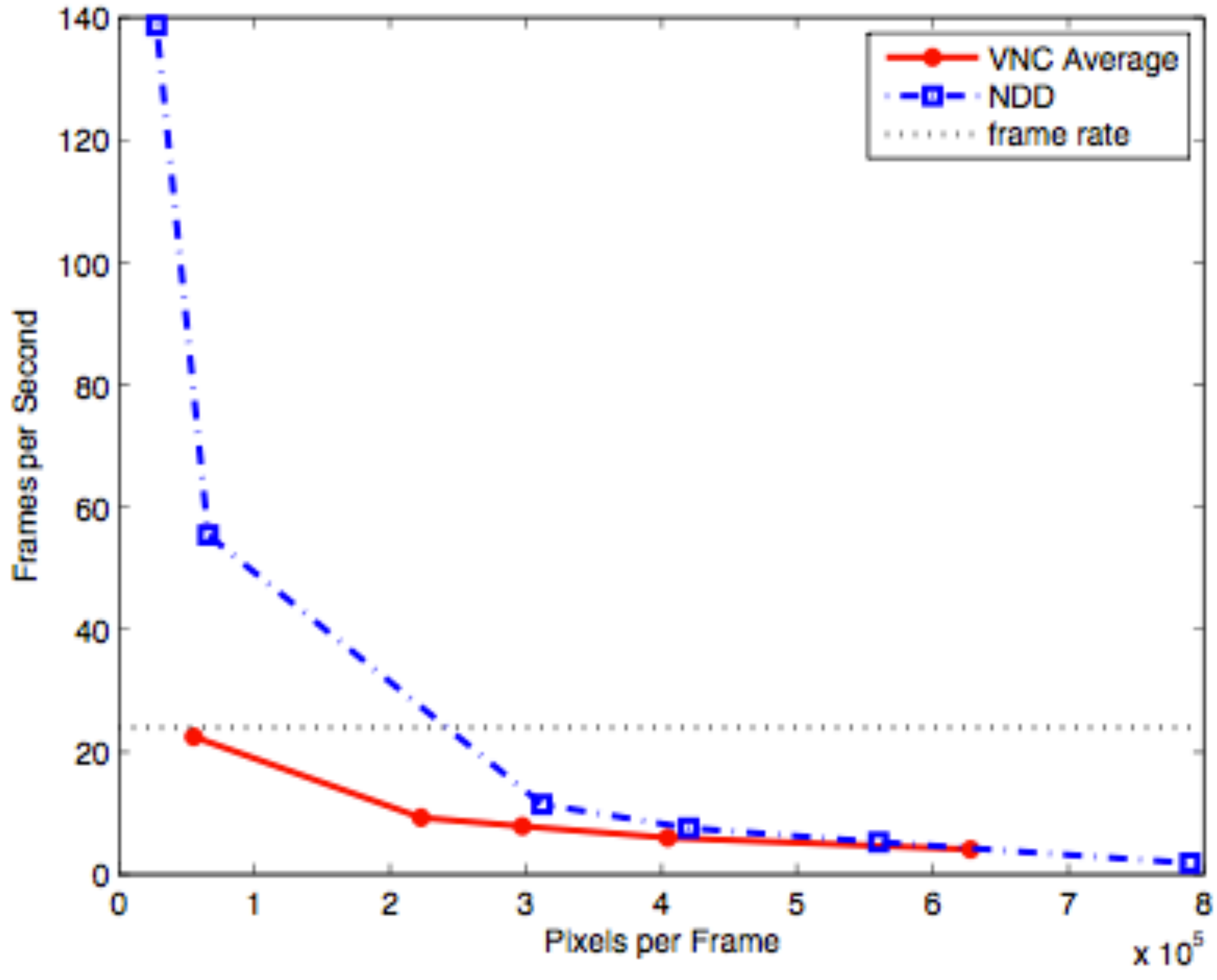
Overhead of Space Navigator Driver



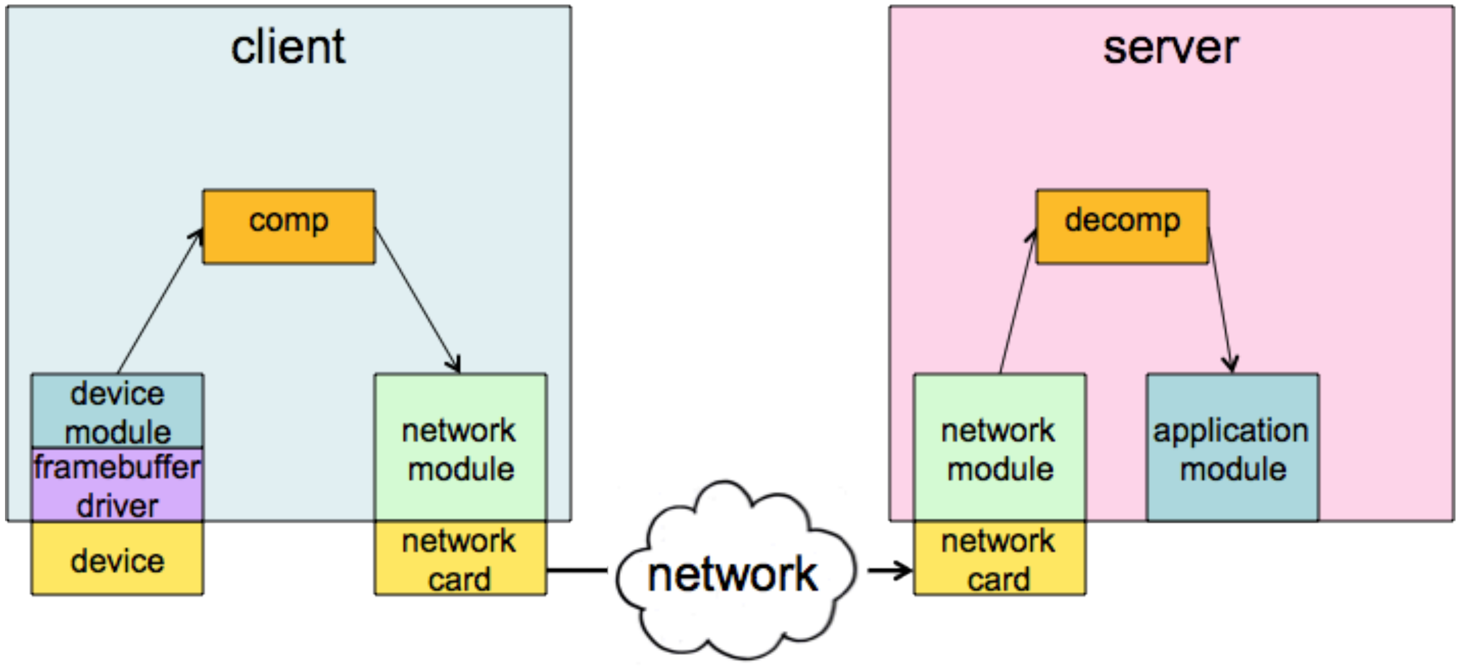
Comparing to VNC



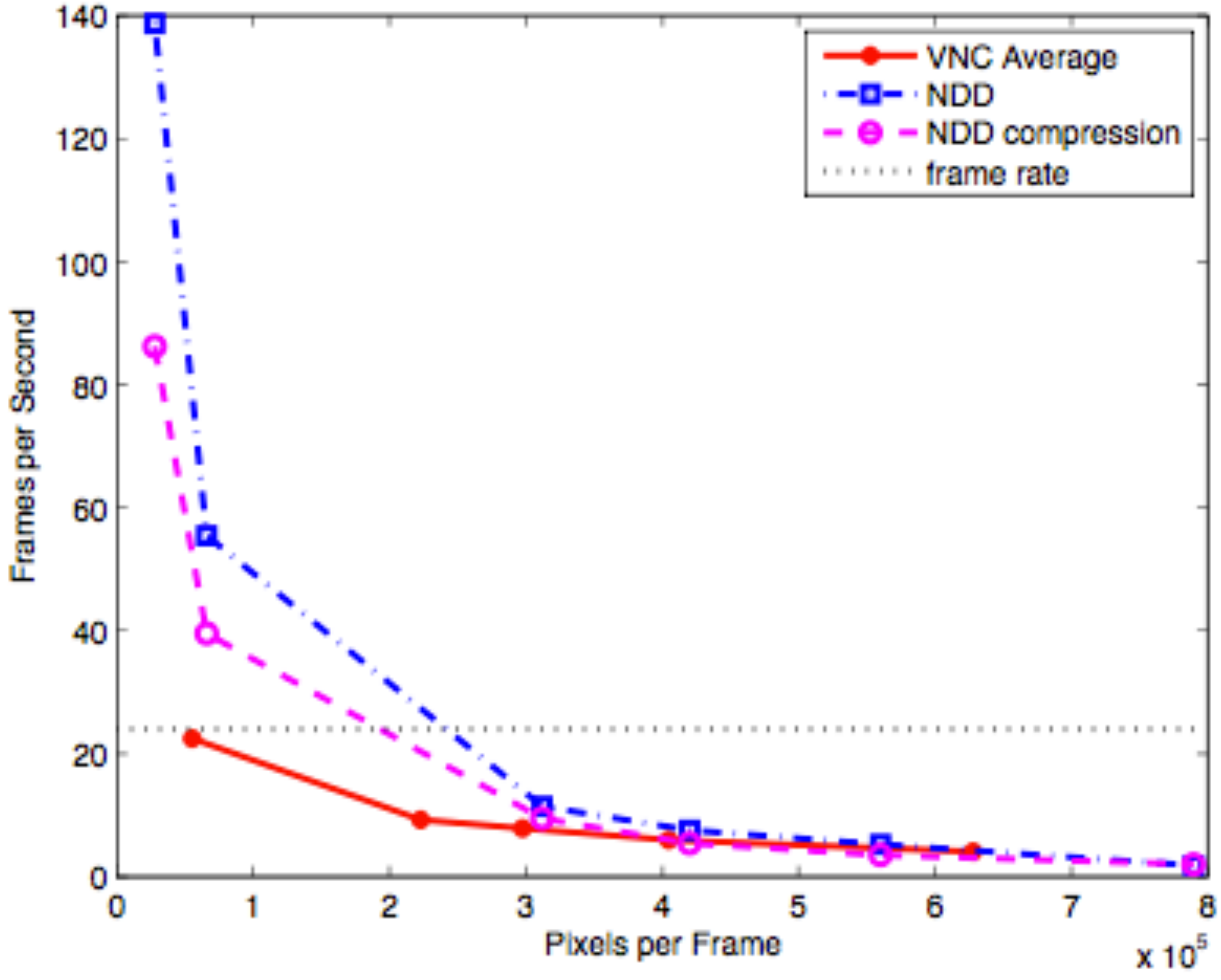
Networked Device Driver vs VNC: Frames per Second



Adding Compression



Networked Device Driver vs VNC: Adding Compression



Summary

- Overhead is order of magnitude less than speed of network
- Performance similar to that of VNC

Conclusion

Summary

- System for I/O over network
- Application sees as driver
- Supports Transformation Modules
- Reasonable performance overhead