

Fault Tolerance

United 737/800 Hacked

“PASS OXYGEN ON anyone?”

Virology 101

“Although particular virus attacks may be guarded against,

no general defense within one domain of reference is possible;

viruses are a natural consequence of a stored-program computation.”

Virology 101

Douglas McIlroy – Bell Laboratories 1989

Multi-Domain Architecture

Multi-Domain Architecture

**Fault Tolerant –
Hardware and Software**

Component Failure Analysis

Virus Prevention at Multiple Levels

What is Multi-Domain Architecture

Divides a system into two parts (Domains):

- 1. Computation (DID)**
- 2. Housekeeping (PAD)**

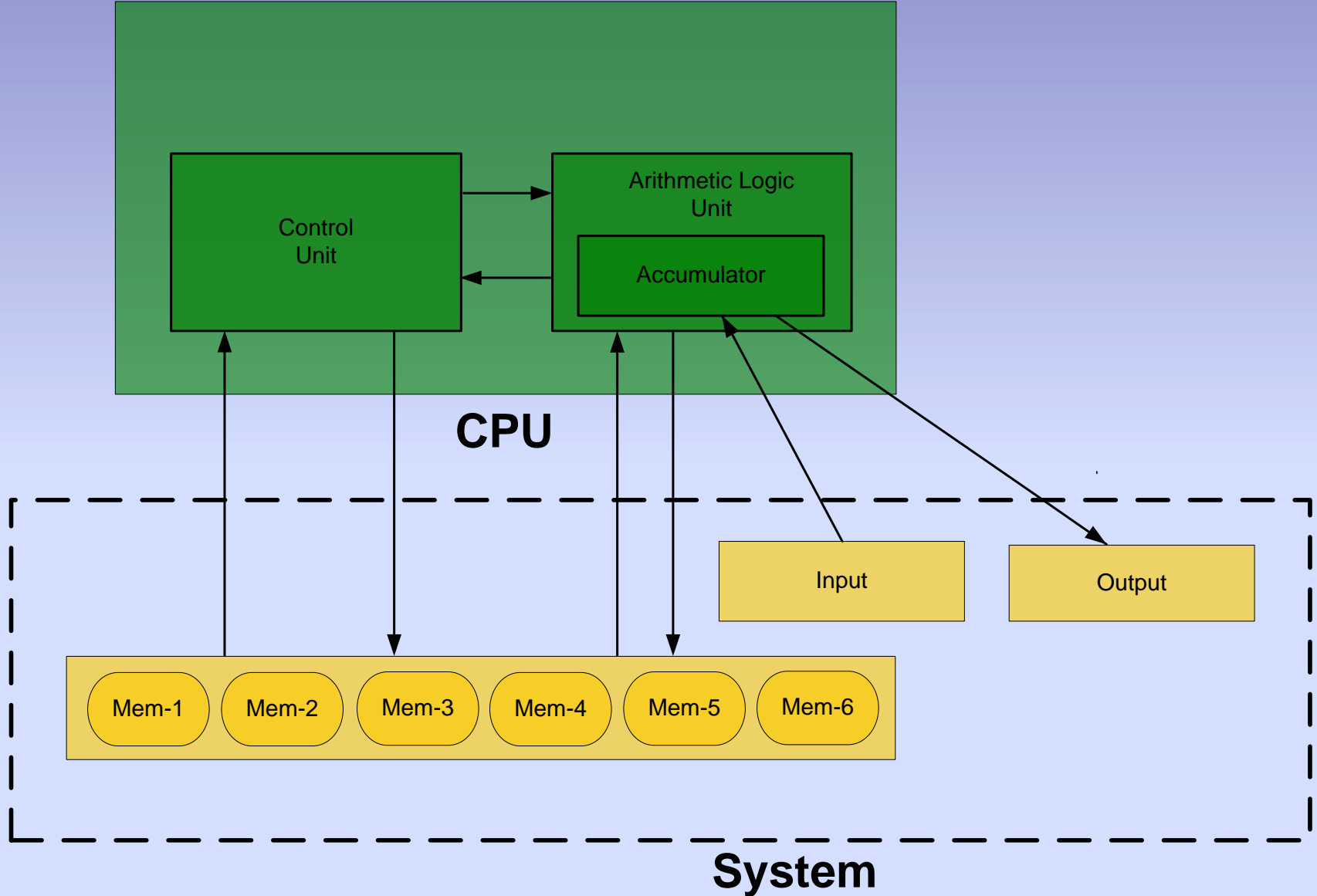
Its an architecture

Can use any old COTS parts and it still works.

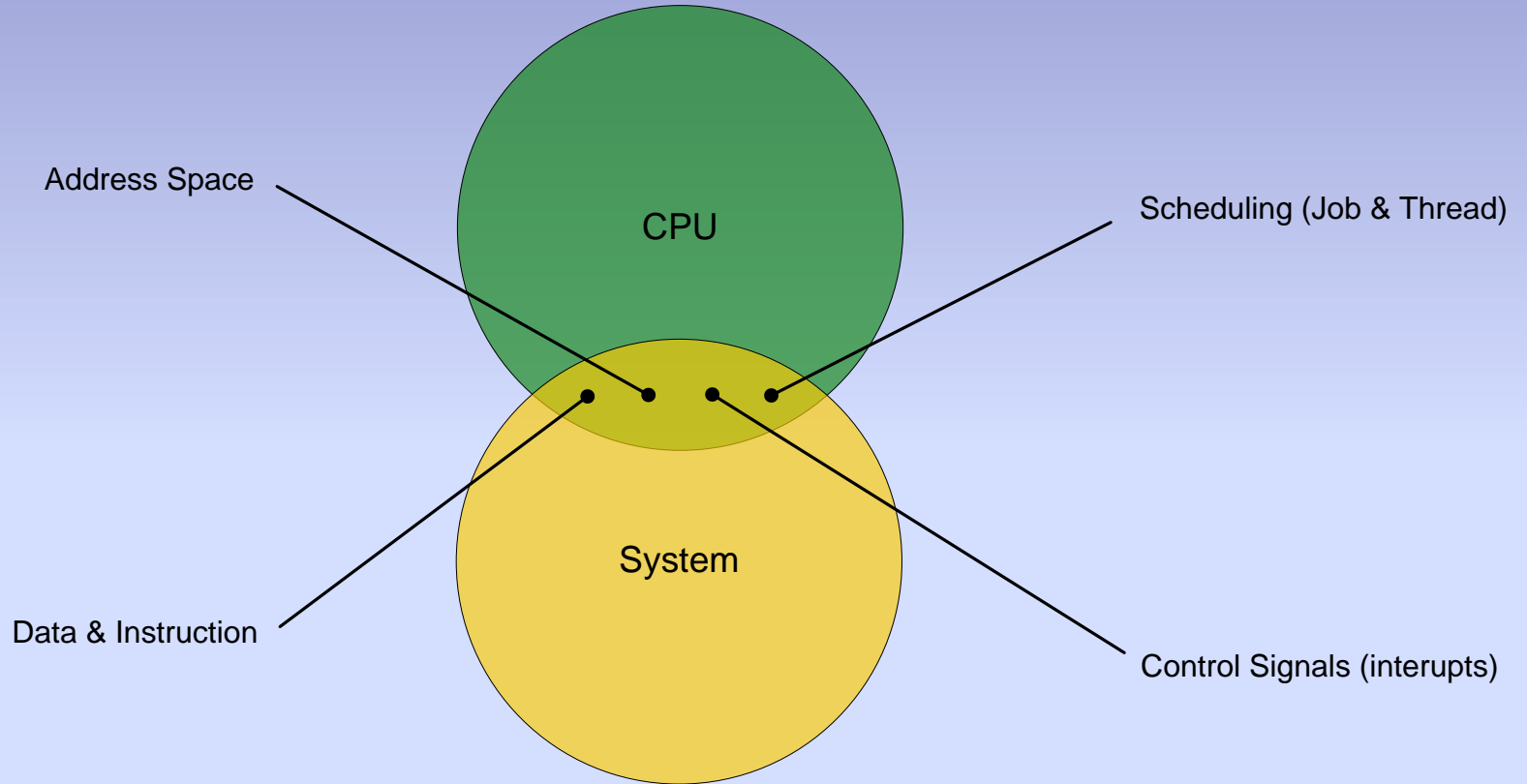
All of the existing software still works.

Graphical Illustration

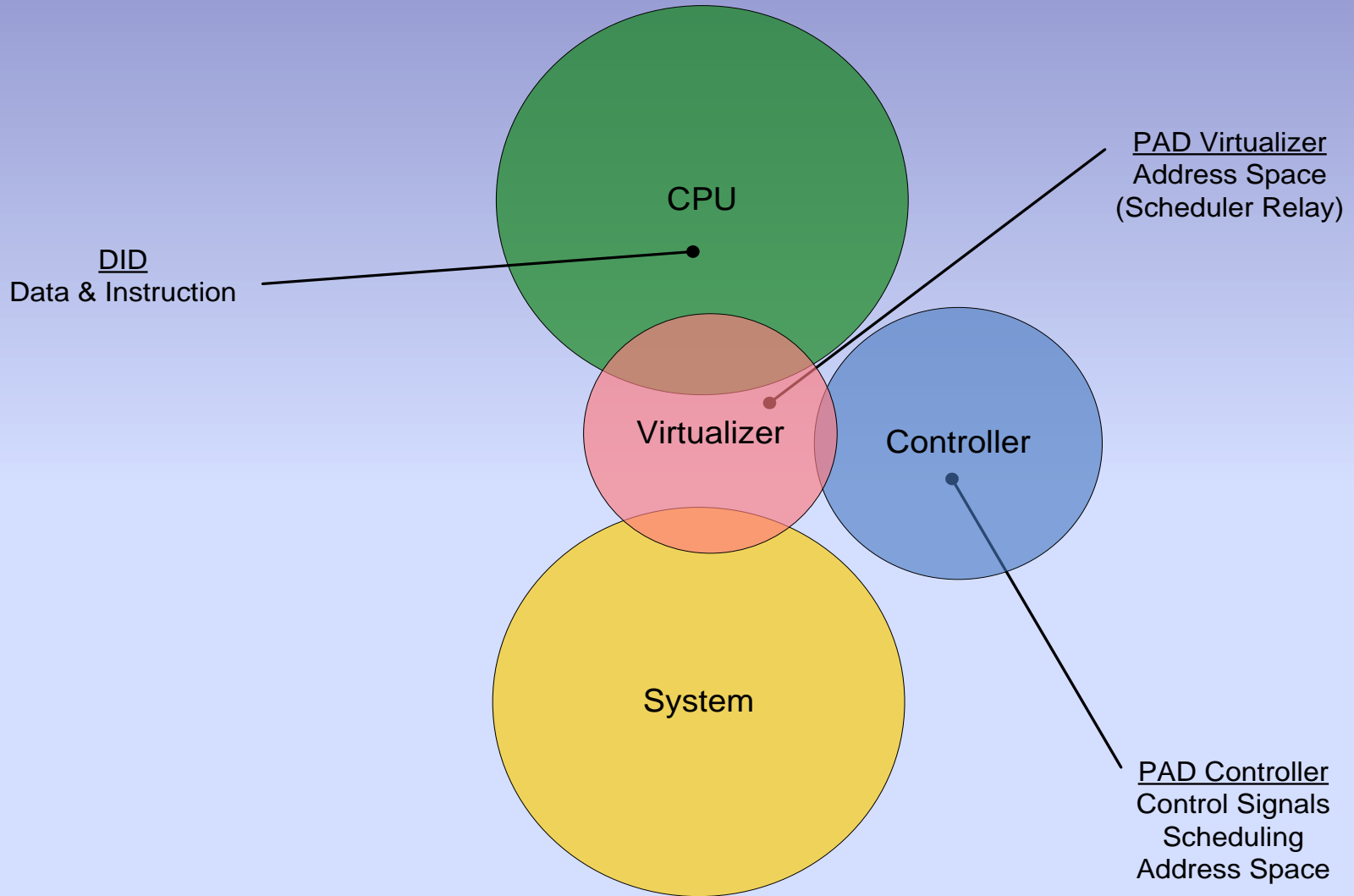
Von Neumann Architecture



Single Domain

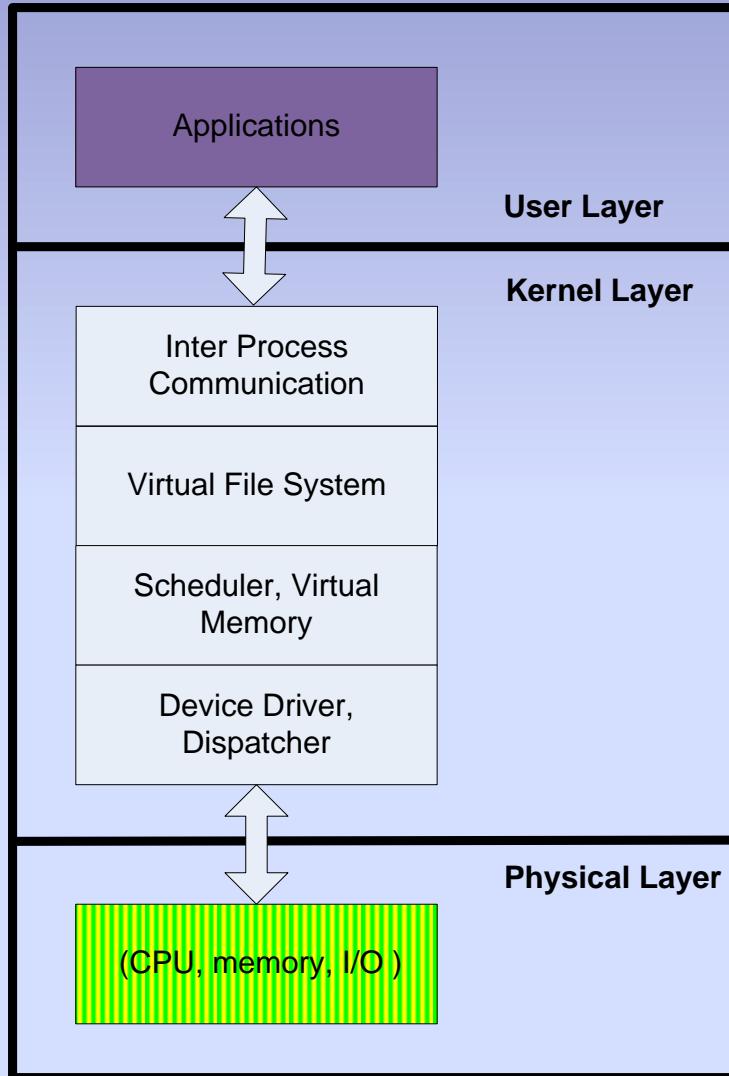


Multi-Domain

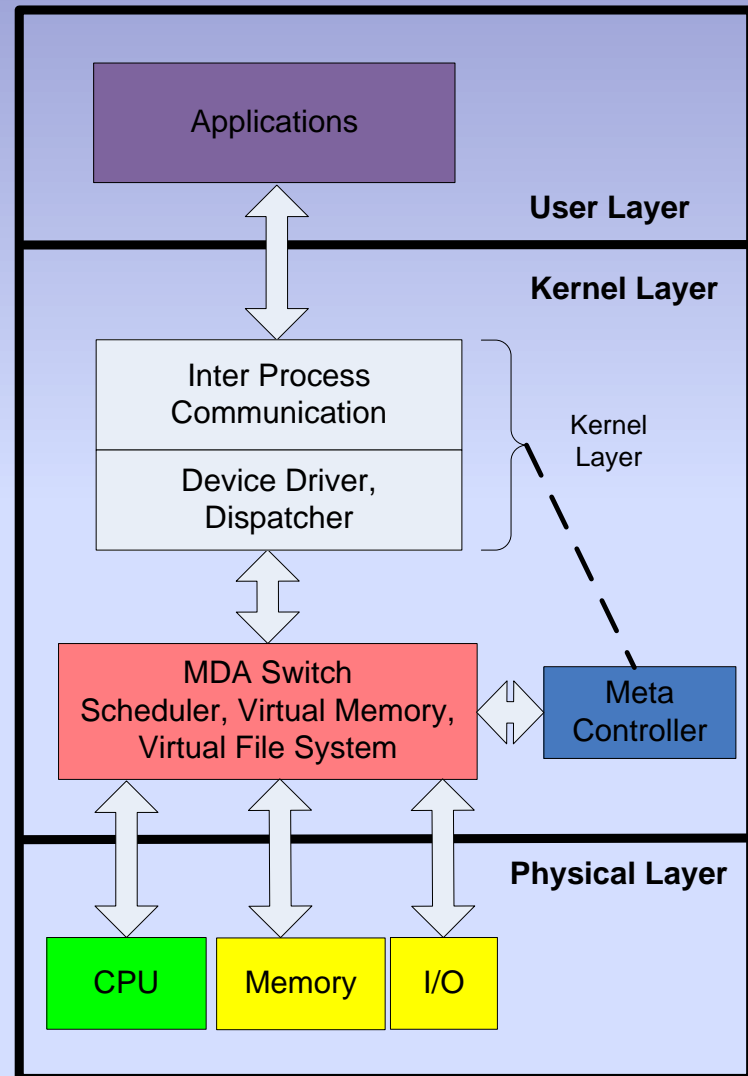


Comparison

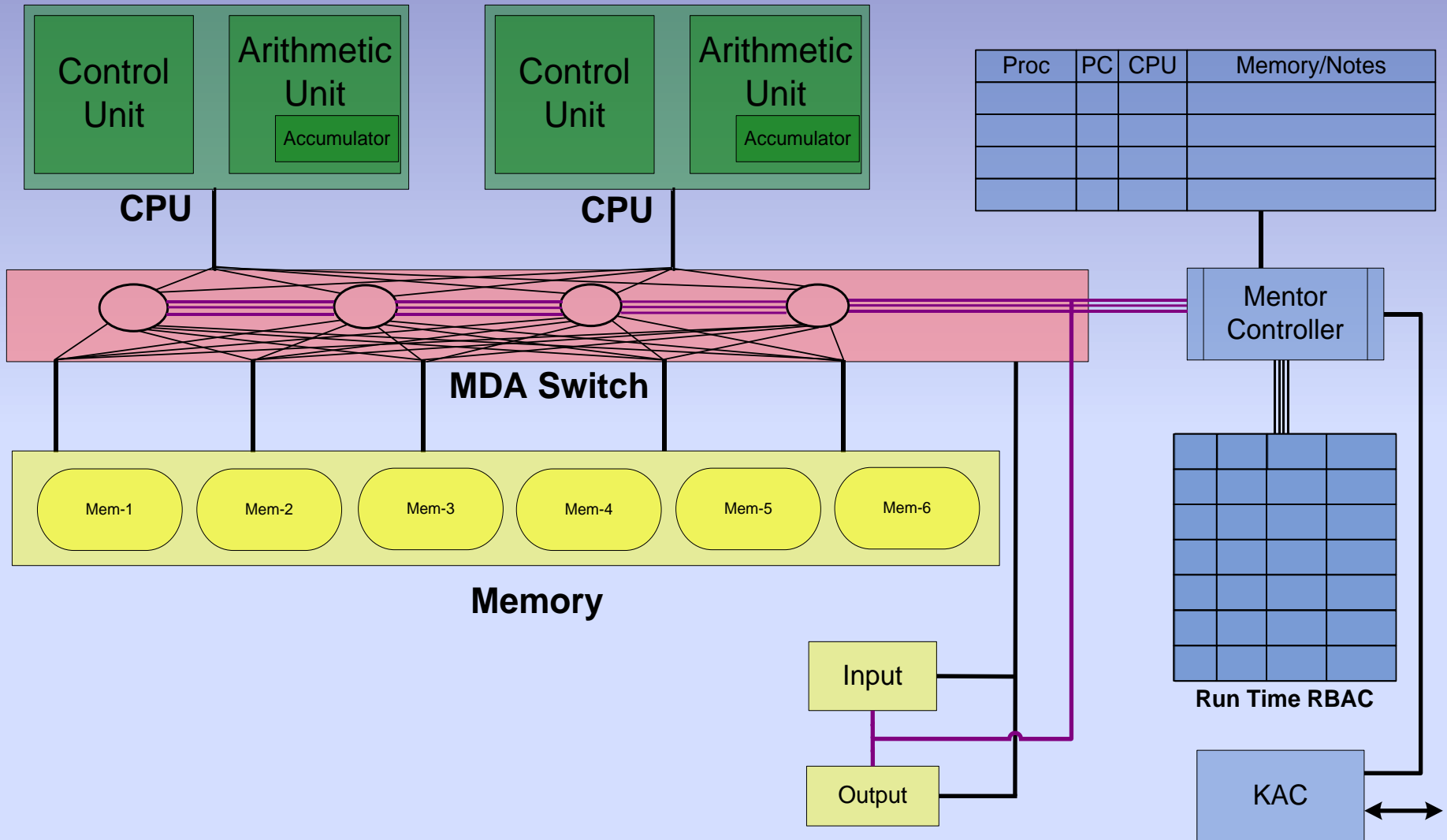
Single Domain



Multiple Domain



Block Diagram



Multi-Domain Architecture

Doesn't do anything different

Does them differently

Does things single domain can't do

FEATURES

FEATURES

- **Hardware Fault Tolerant**

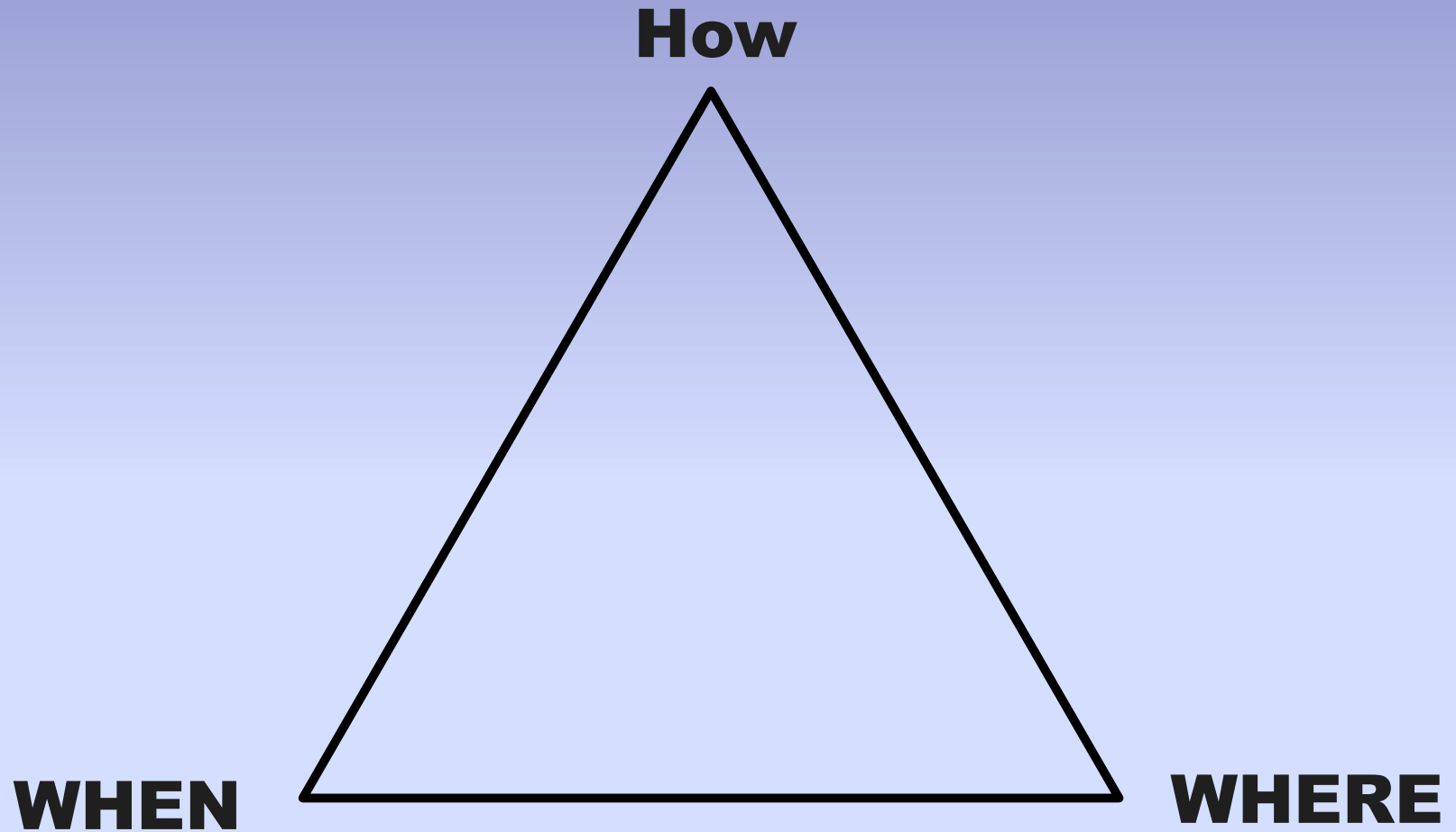
FEATURES

- **Hardware Fault Tolerant**
- **Software Fault Tolerant**

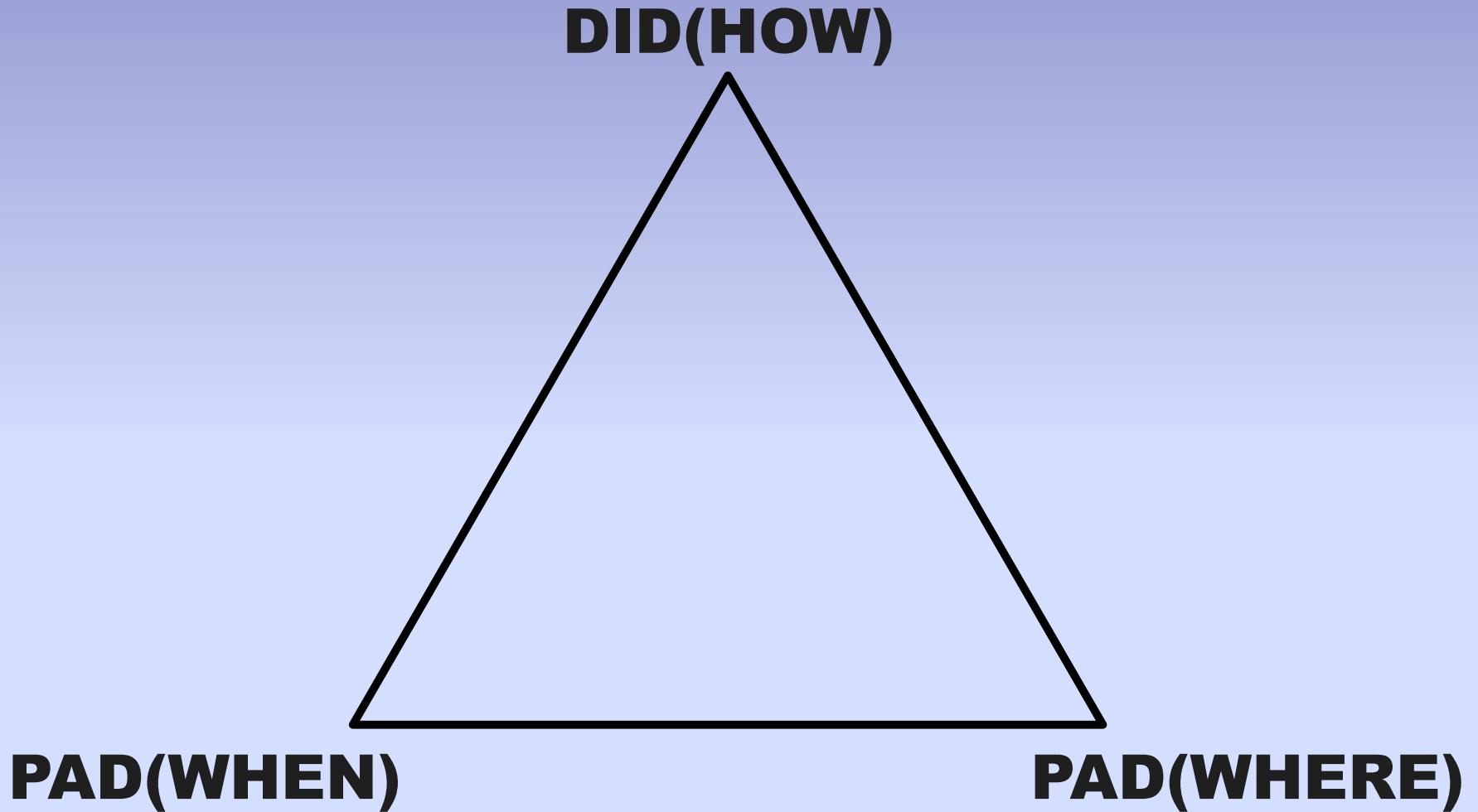
FEATURES

- **Hardware Fault Tolerant**
- **Software Fault Tolerant**
- **Virus Prevention**

Attack Triangle



Attack Triangle



FEATURES

- **Hardware Fault Tolerant**
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- **Virus Prevention**
- **Fault isolation**

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- **Reconfigurable HW and SW**

FEATURES

- **Hardware Fault Tolerant**
- **Software Fault Tolerant**
- **Virus Prevention**
- **Fault isolation**
- **Reconfigurable HW and SW**
- **Combinatorial Mathematics**

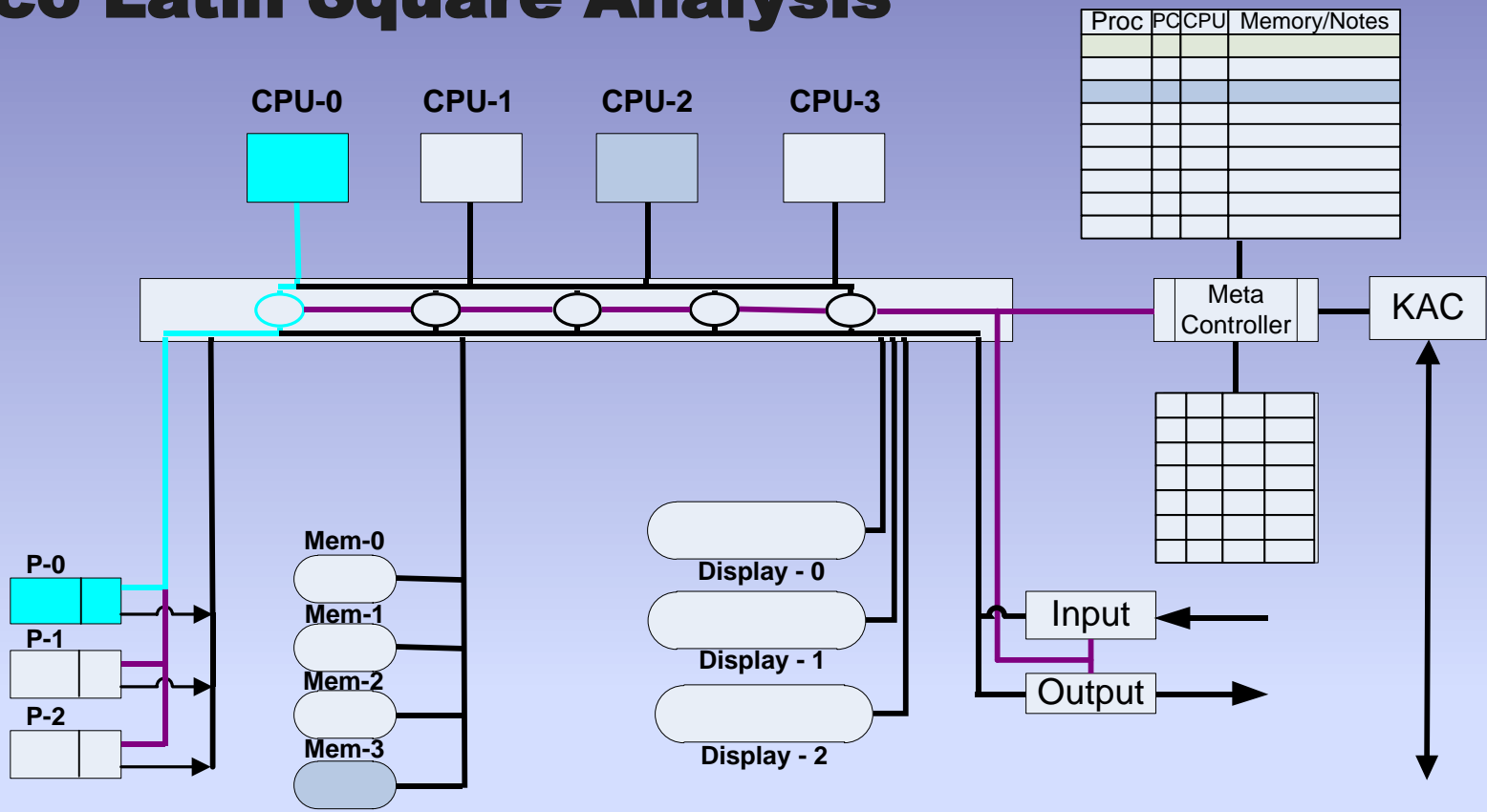
Graphical Example

Simultaneous Failures

Hardware Failure

Virus Problem

Graeco Latin Square Analysis



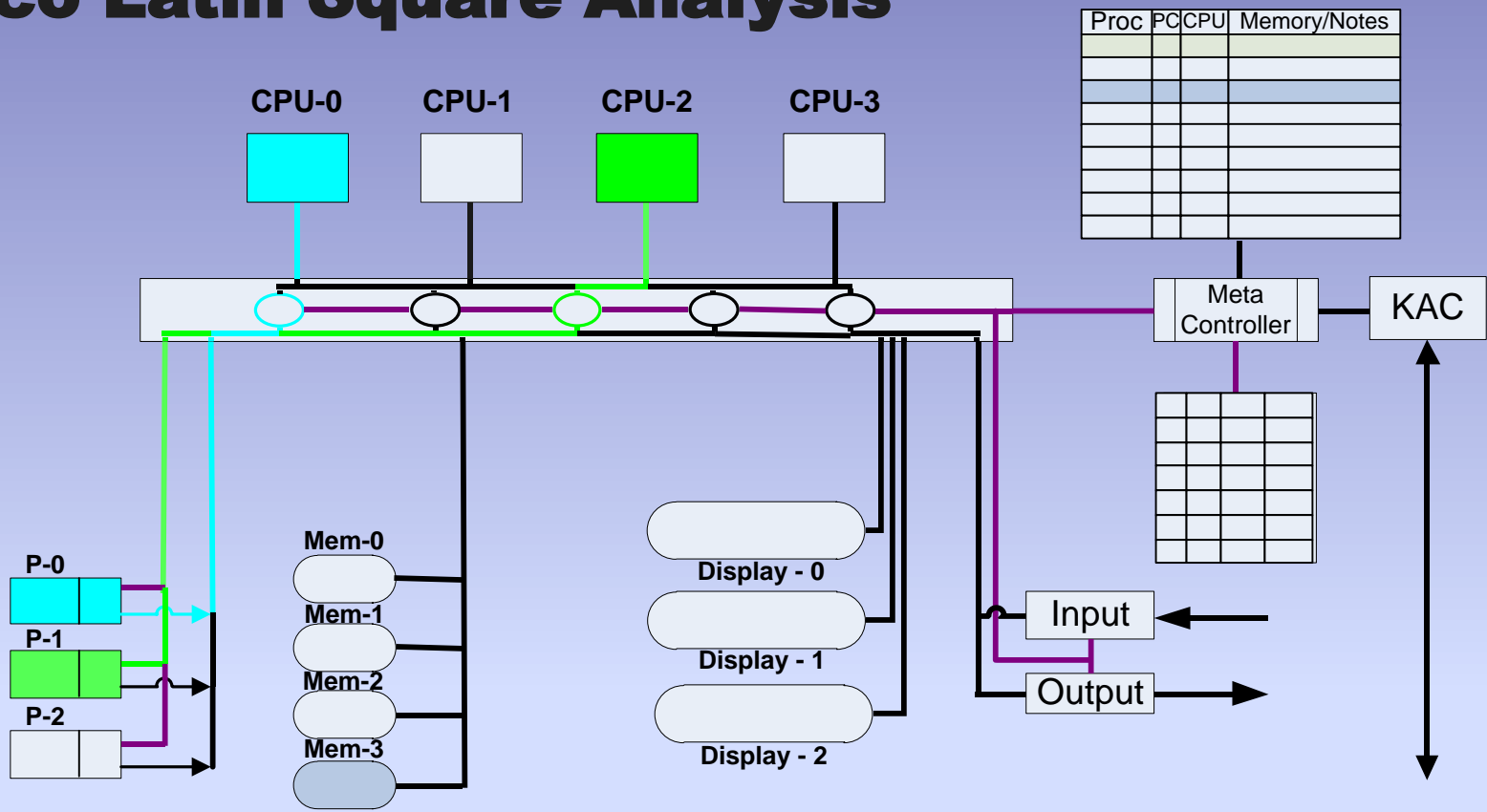
Graeco-Latin Square

Hardware			
	CPU-0	CPU-2	CPU-3
P-0			
P-1			
P-2			

Graeco-Latin Square

Process Time			
	CPU-0	CPU-2	CPU-3
P-0			
P-1			
P-2			

Graeco Latin Square Analysis



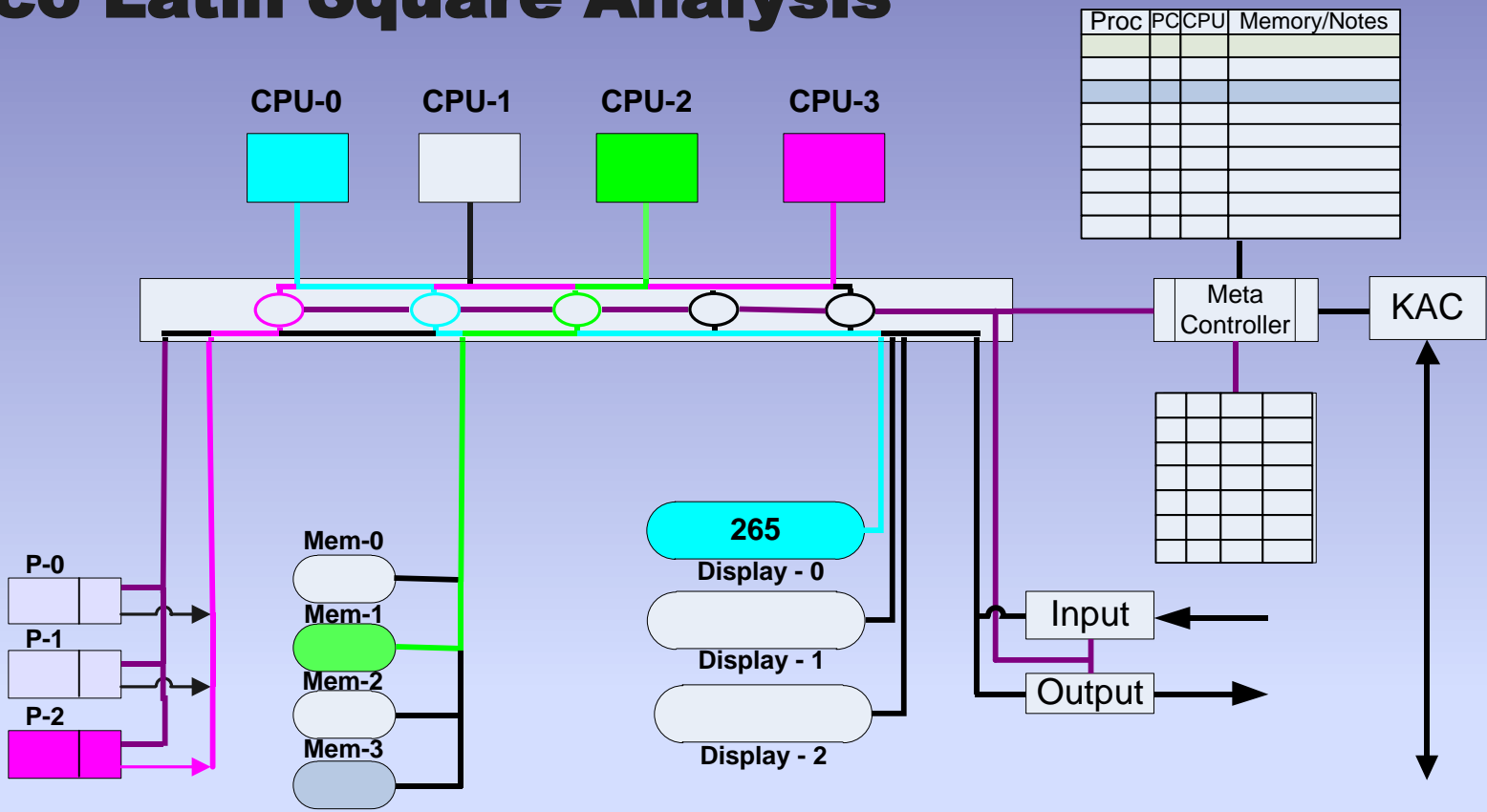
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Process Time			
	CPU-0	CPU-2	CPU-3
P-0			
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P-2			

Graeco Latin Square Analysis



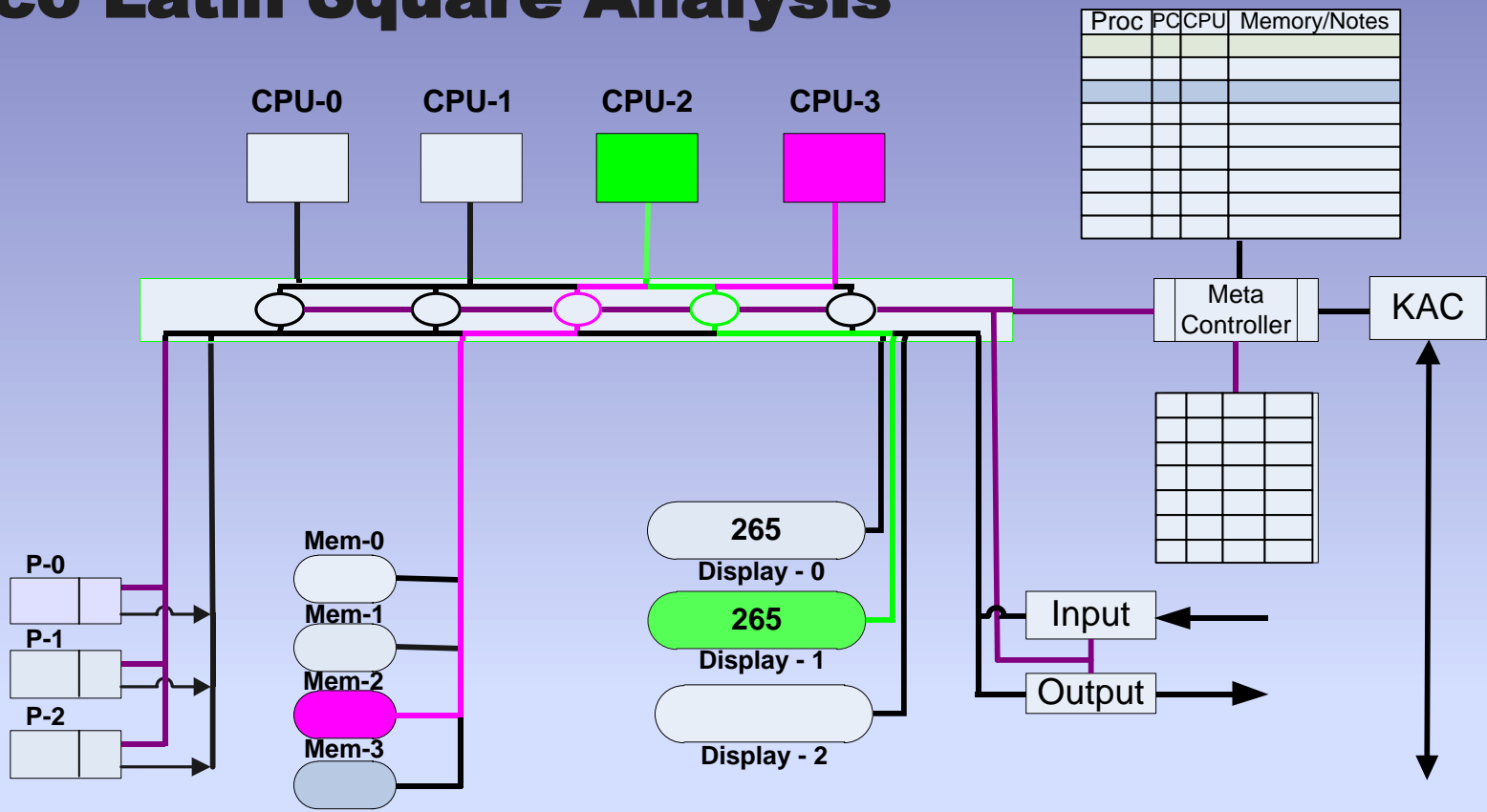
Graeco-Latin Square

Hardware			
	CPU-0	CPU-2	CPU-3
P-0	265		
P-1			
P-2			

Graeco-Latin Square

Process Time			
	CPU-0	CPU-2	CPU-3
P-0	52		
P-1			
P-2			

Graeco Latin Square Analysis



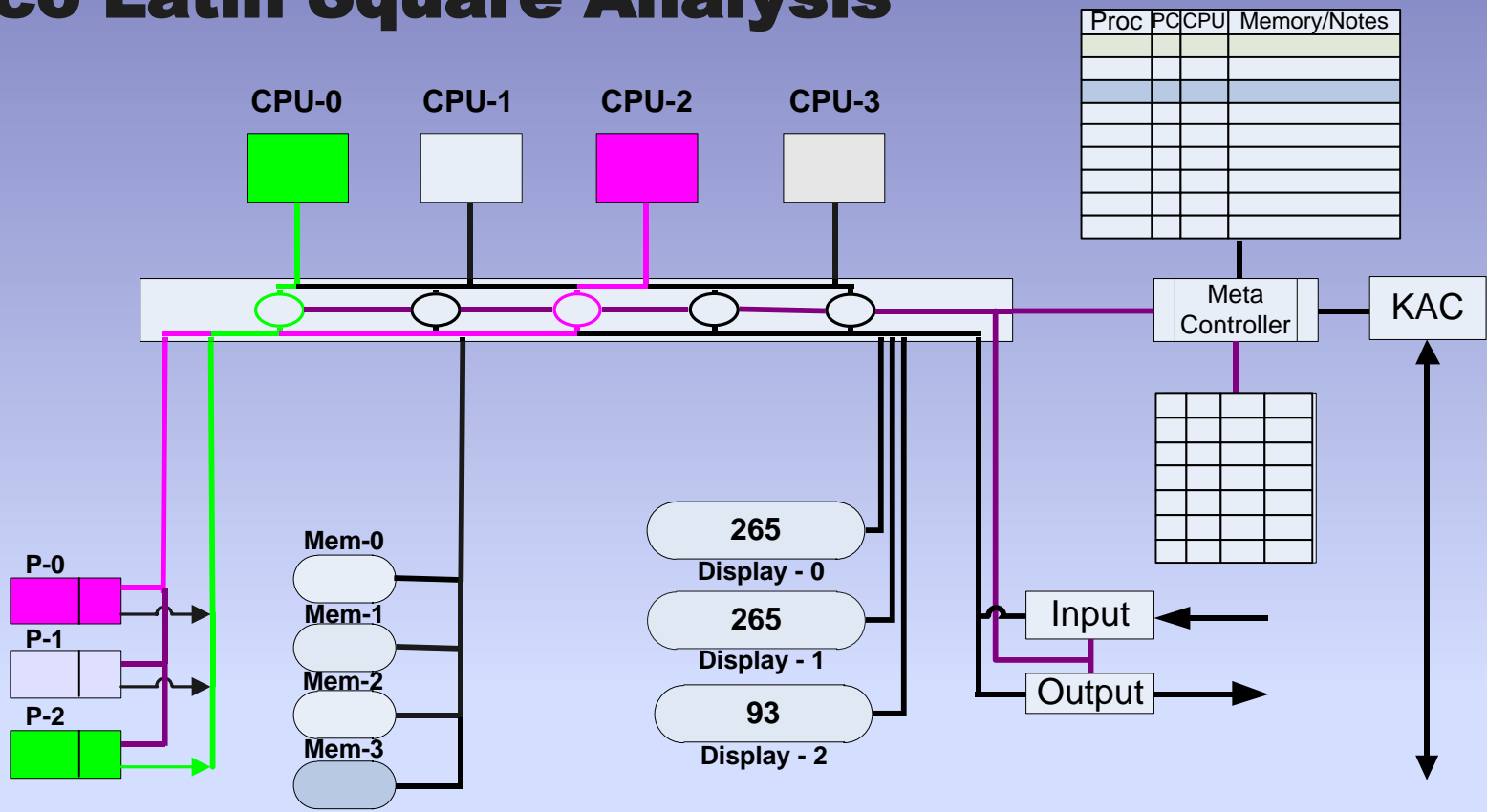
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Hardware			
	CPU-0	CPU-2	CPU-3
P-0	265		
P-1		265	
P-2			

Graeco-Latin Square

Process Time			
	CPU-0	CPU-2	CPU-3
P-0	52		
P-1		155	
P-2			

Graeco Latin Square Analysis



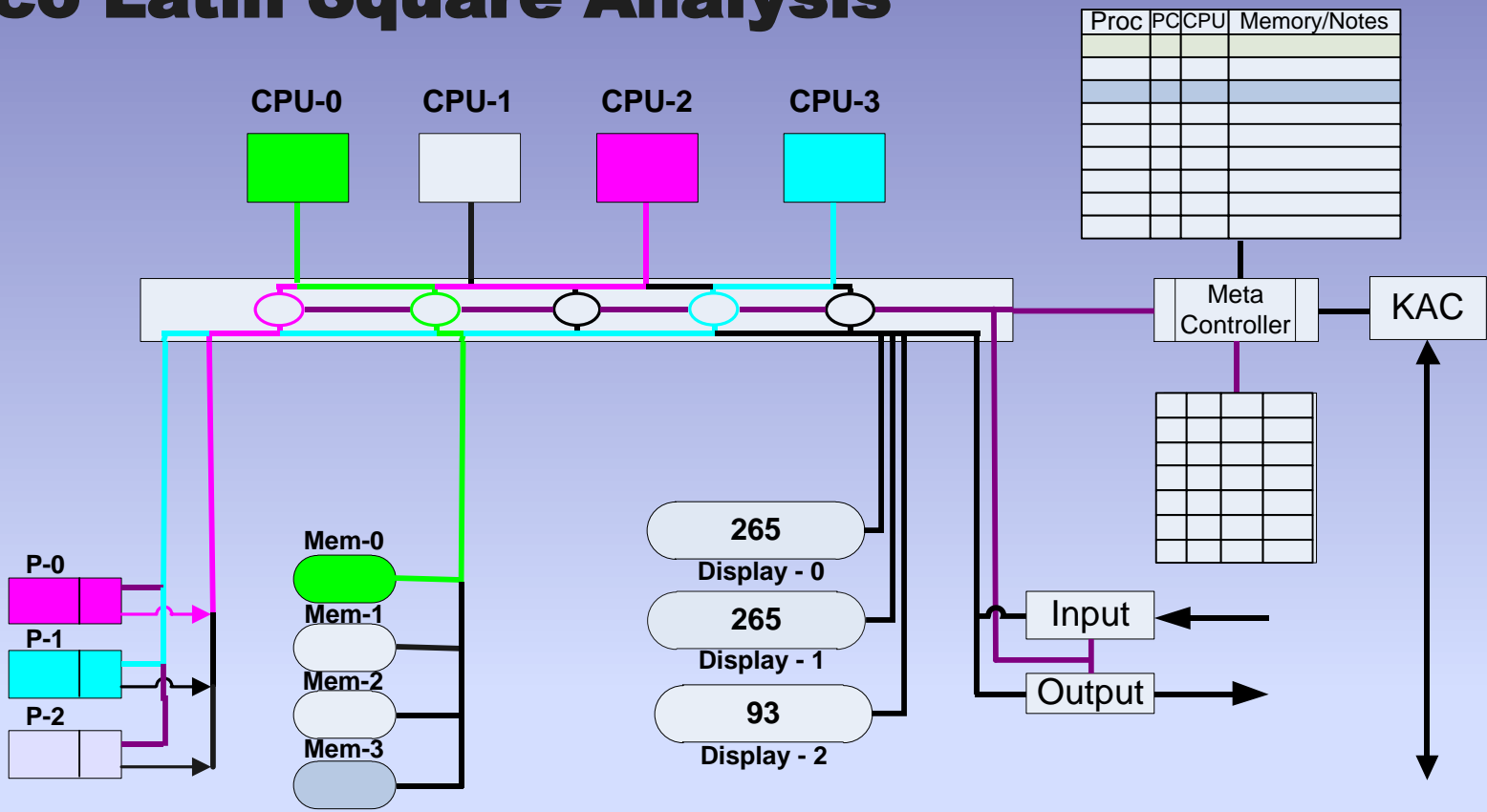
Graeco-Latin Square

Hardware			
	CPU-0	CPU-2	CPU-3
P-0	265		
P-1		265	
P-2			93

Graeco-Latin Square

Process Time			
	CPU-0	CPU-2	CPU-3
P-0	52		
P-1		155	
P-2			52

Graeco Latin Square Analysis



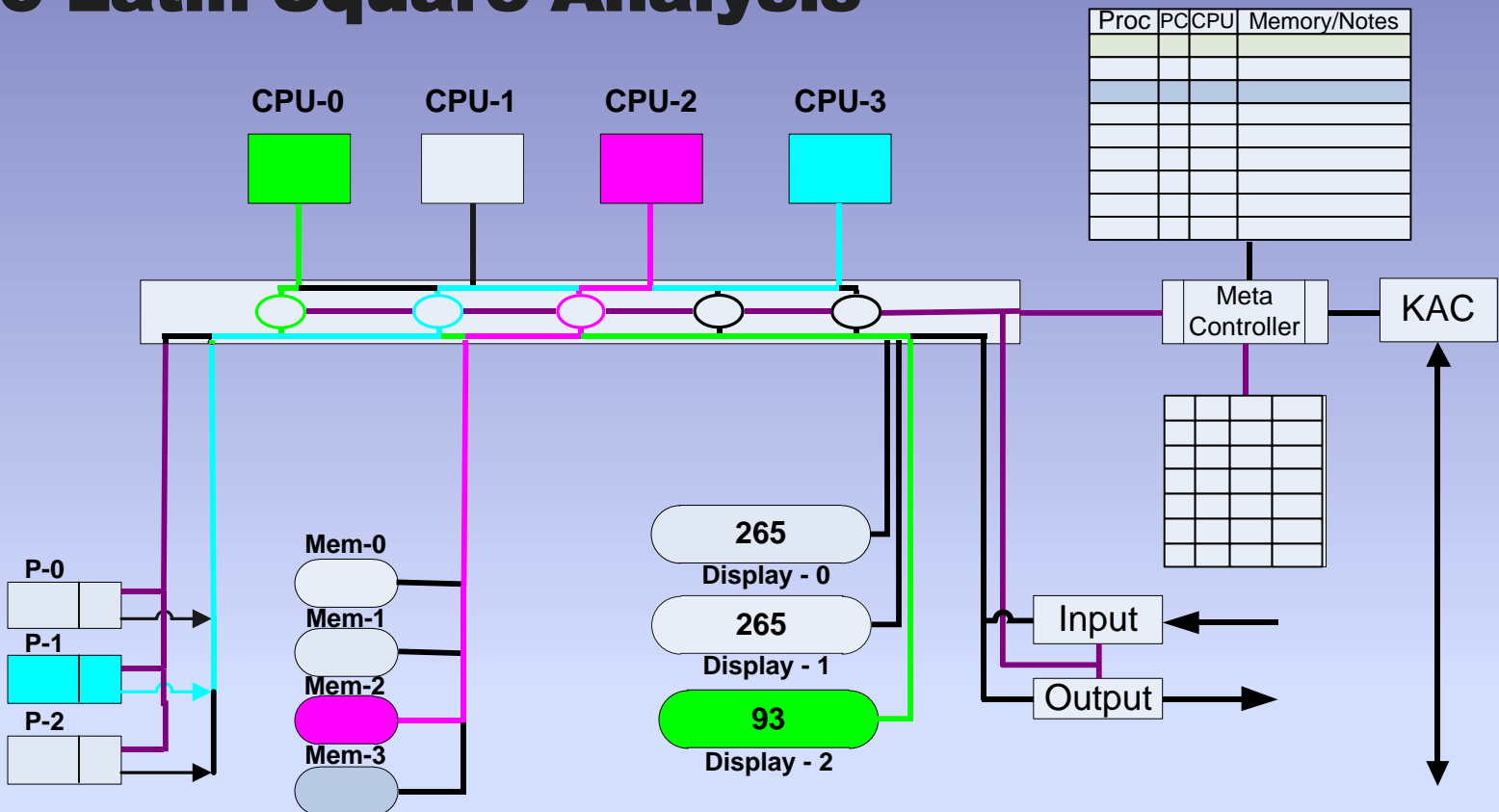
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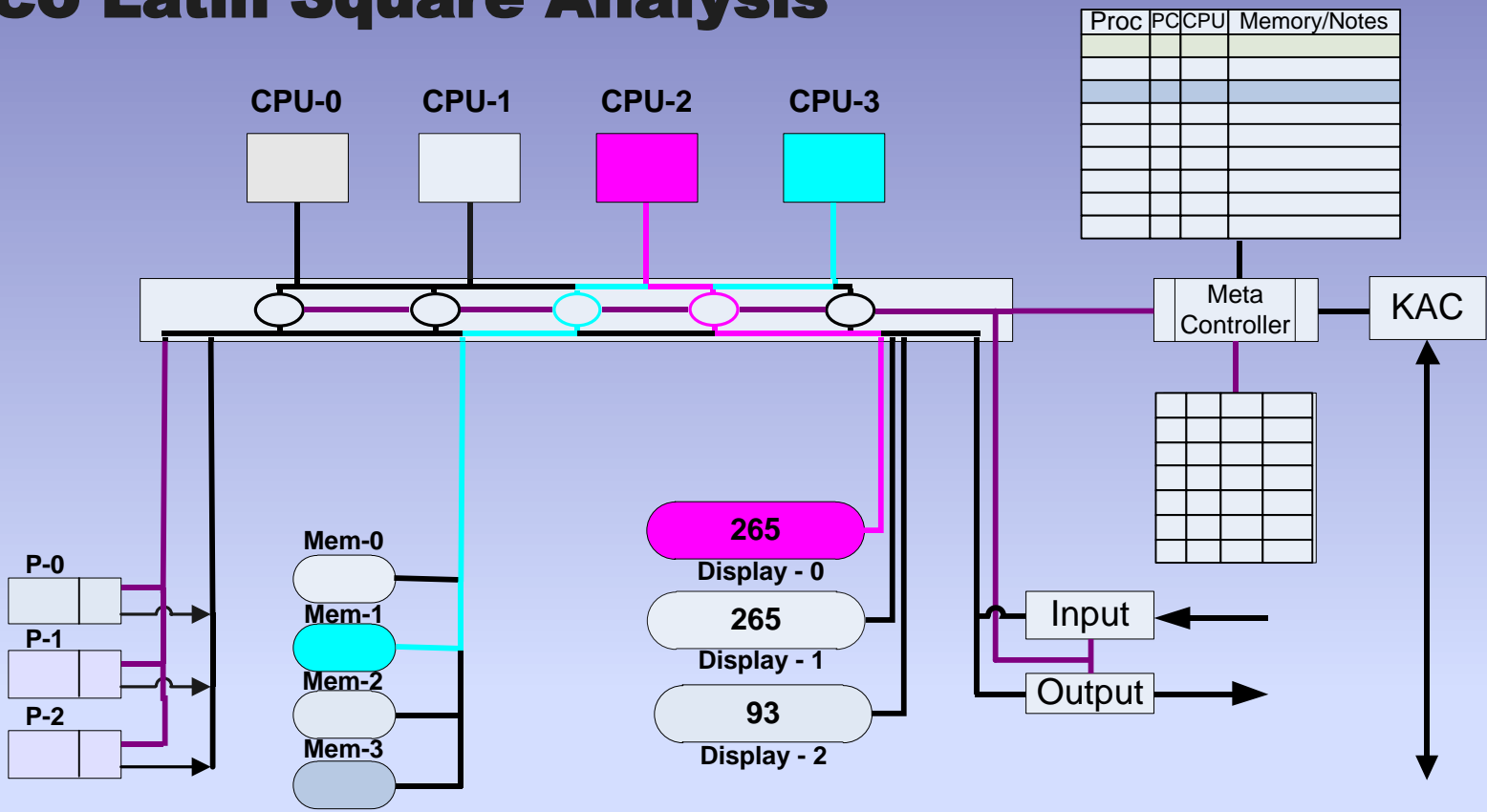
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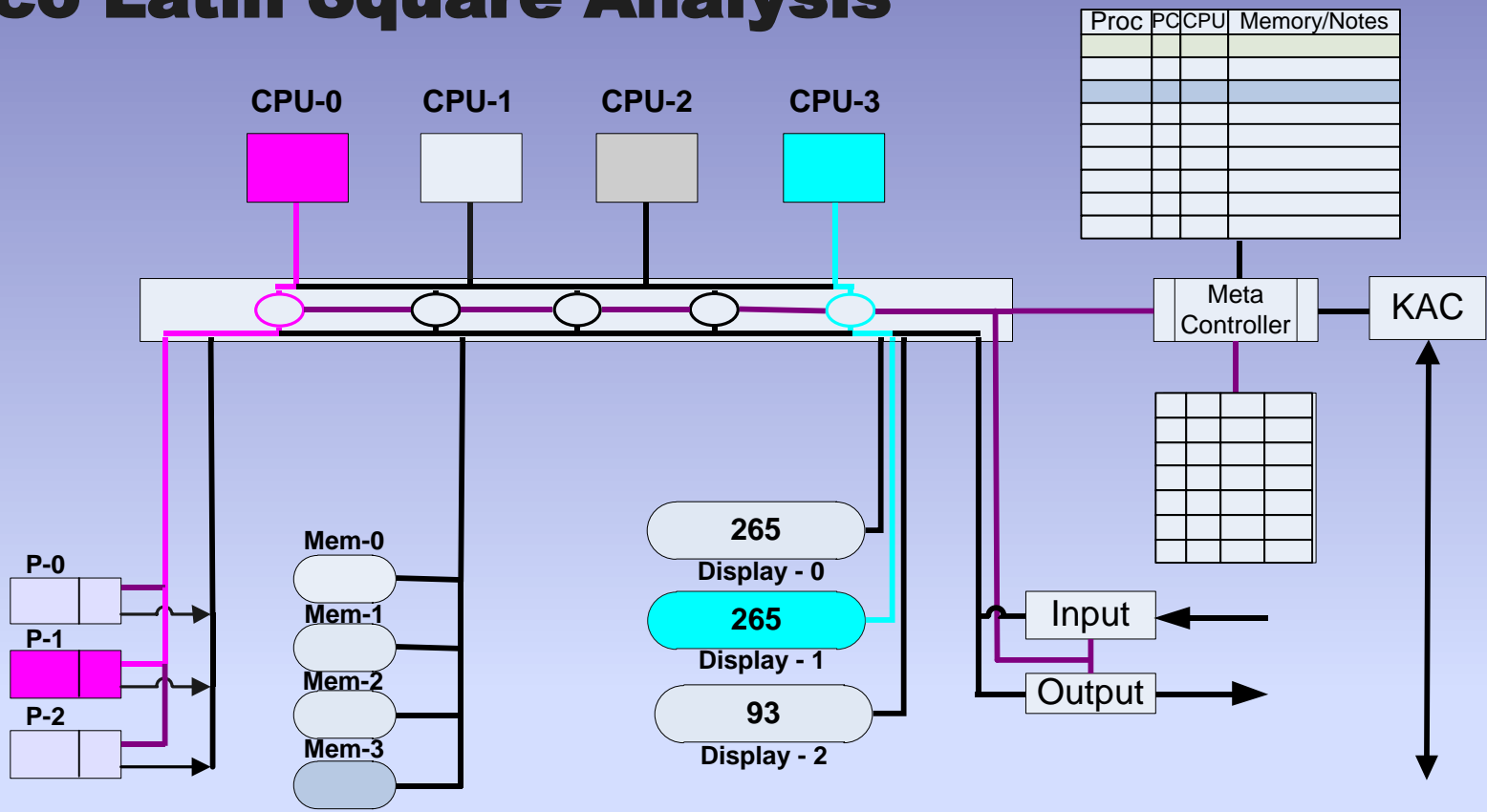
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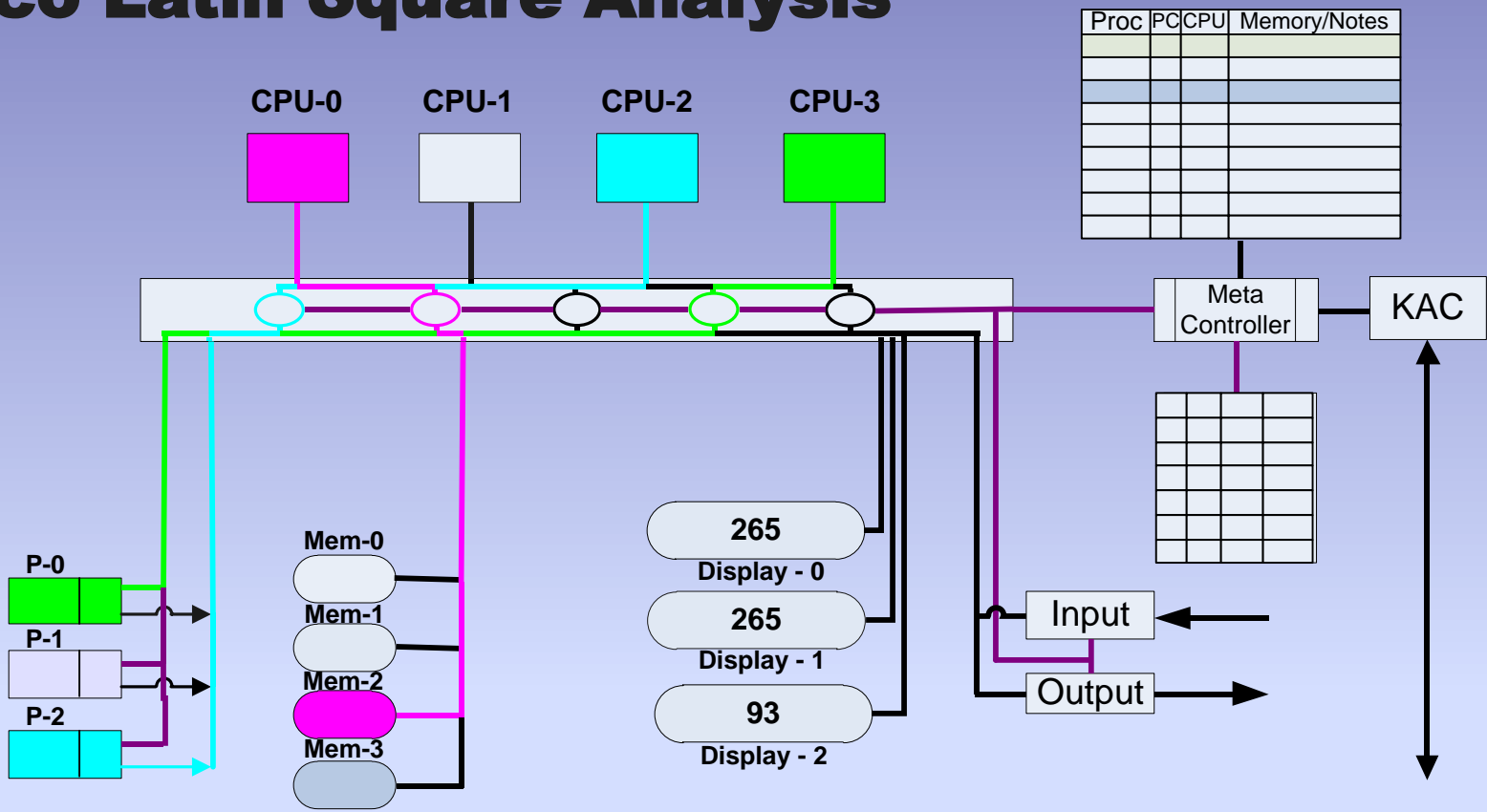
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P-1		265	265
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P-2	155		52

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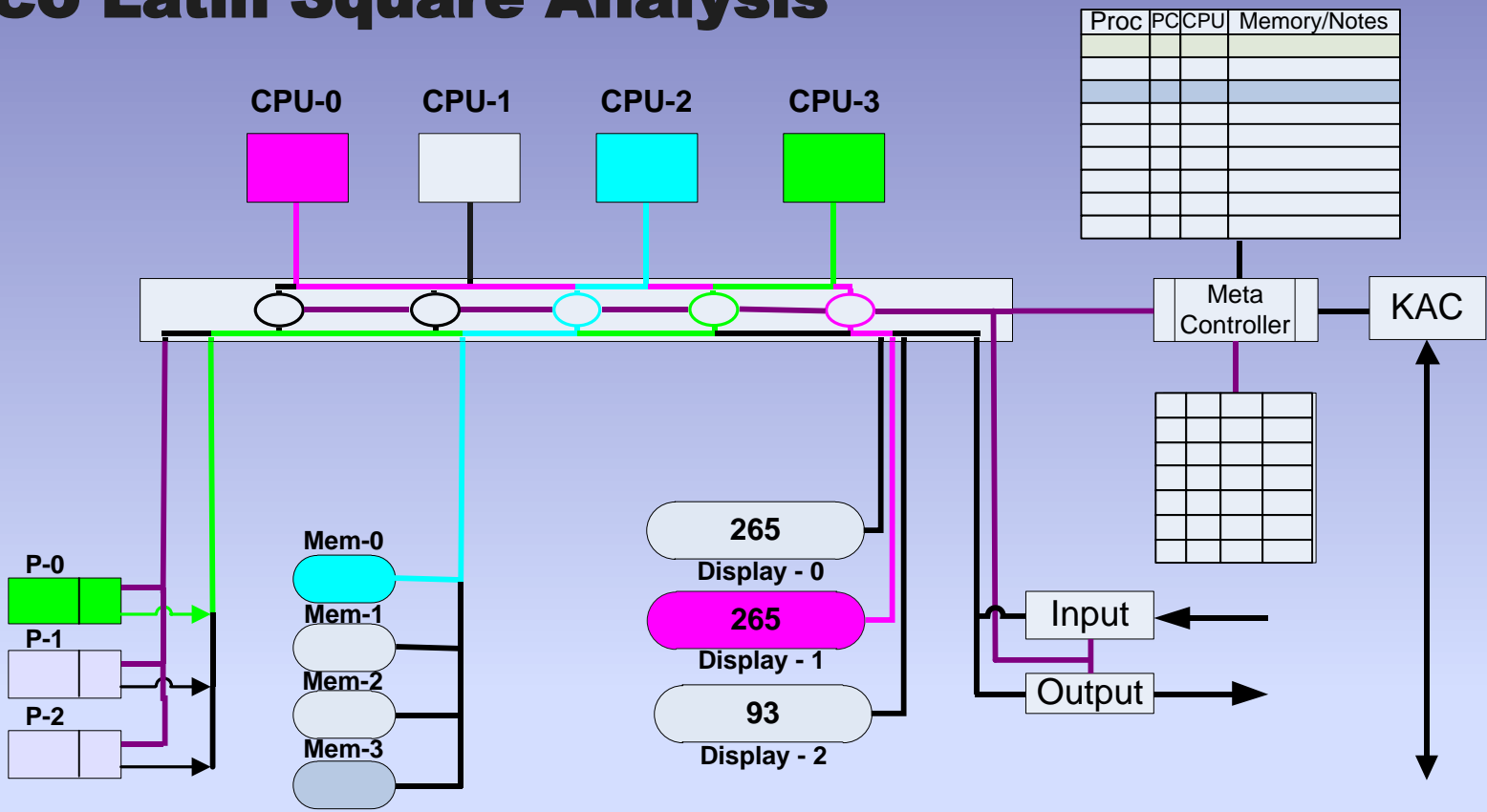
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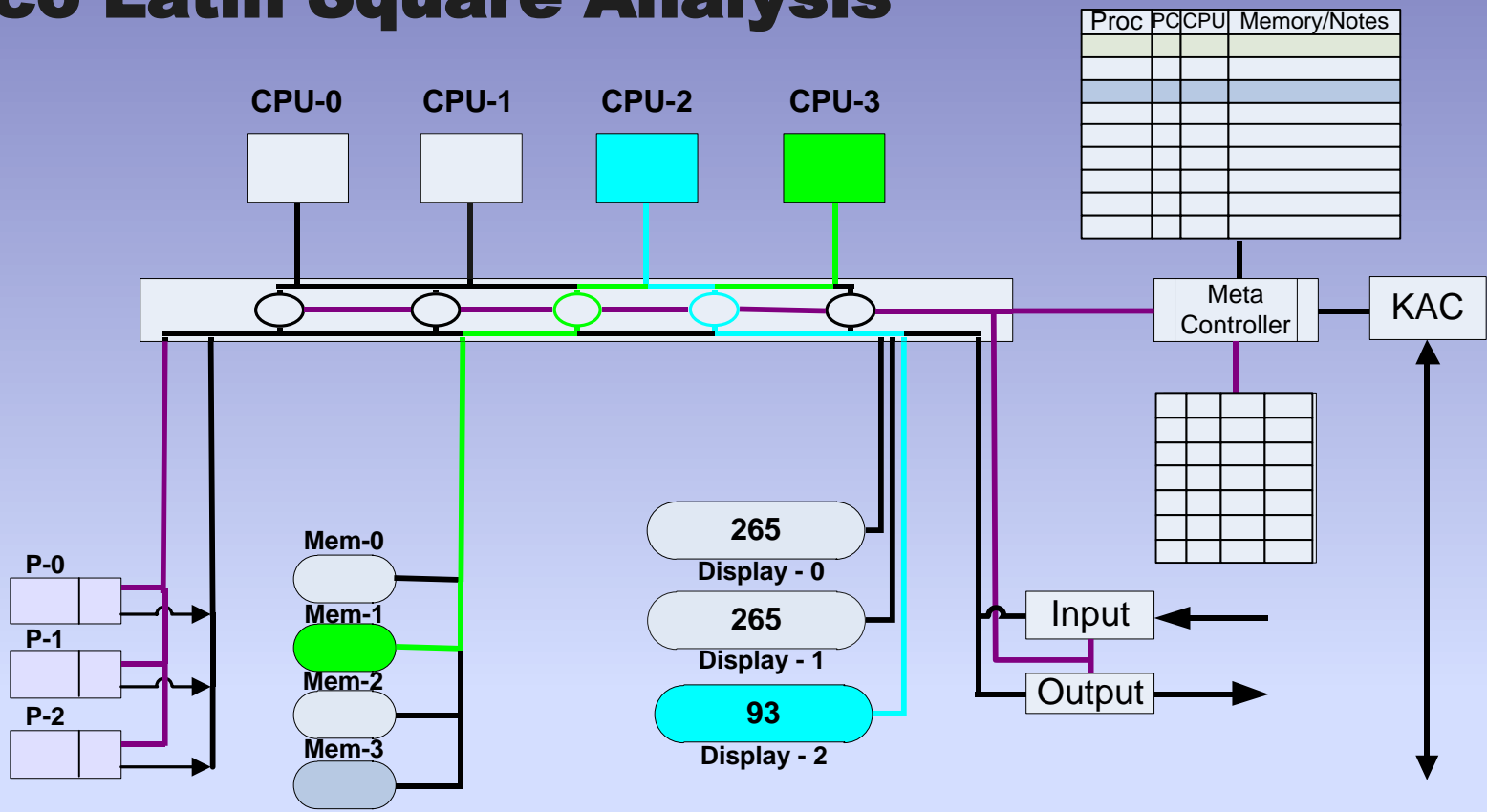
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P-1	265	265	265
P-2	93		93

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P-1	52	155	52
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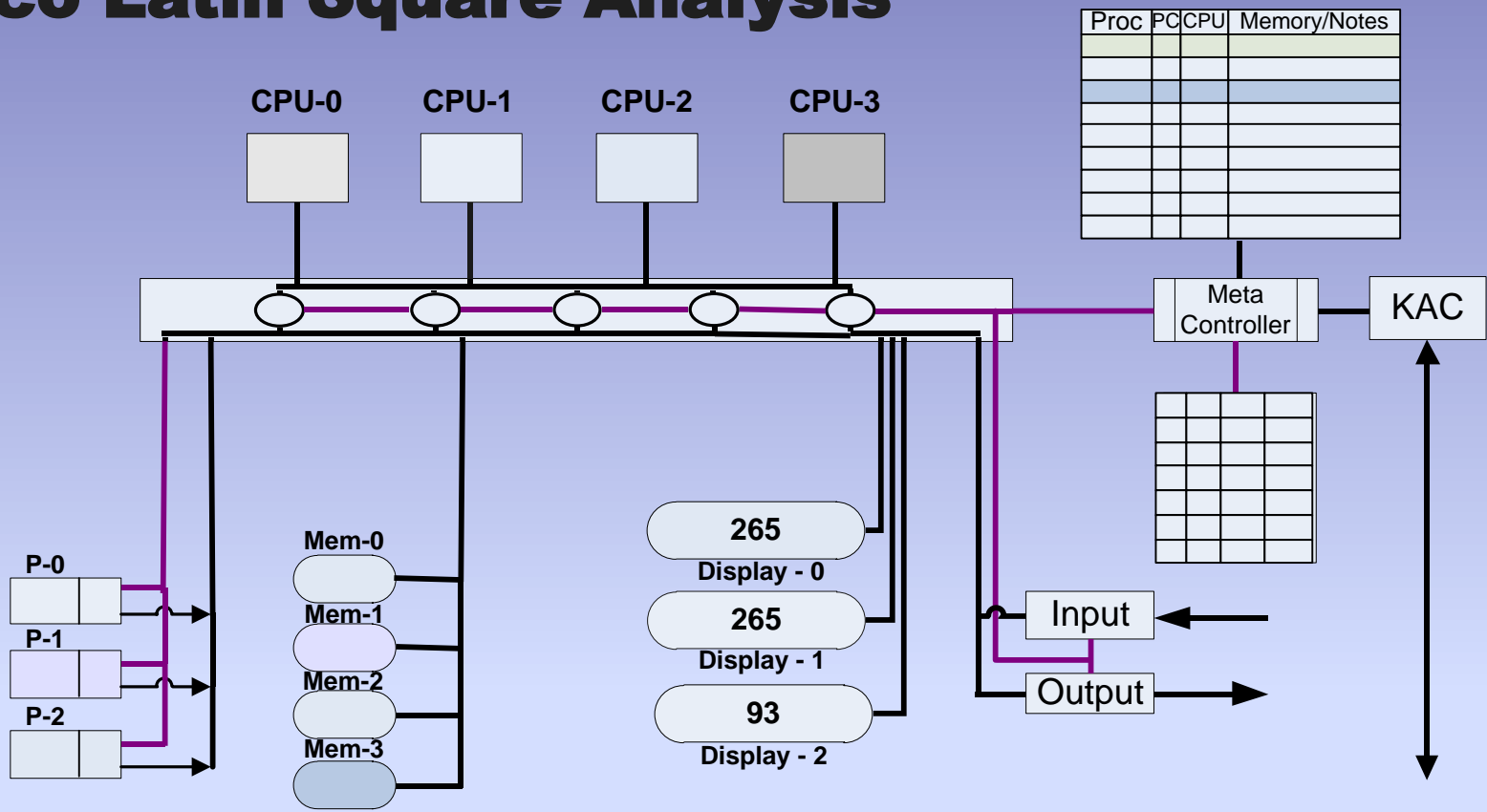
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P-1	265	265	265
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P-0	52	52	155
P-1	52	155	52
P-2	155	52	52

DIFFERENCES & BENEFITS

Single Domain

- **Fixed System**
 - Limited fault analysis

Multi Domain

- **Reconfigurable System**
 - Component level analysis

DIFFERENCES & BENEFITS

Single Domain

- **Fixed System**
 - Limited fault analysis
- **Virus Protection**
 - 35 year legacy

Multi Domain

- **Reconfigurable System**
 - Component level analysis
- **Virus Protection**
 - Disjoint domains
 - Reconfigurable system

DIFFERENCES & BENEFITS

Single Domain

- **Fixed System**
 - Limited fault analysis
- **Virus Protection**
 - 35 year legacy
- **Computational Speed**
 - CPU does all the work

Multi Domain

- **Reconfigurable System**
 - Component level analysis
- **Virus Protection**
 - Disjoint domains
 - Secure communications
- **Computational Speed**
 - Overhead on separate RISC

DIFFERENCES & BENEFITS

Single Domain

- **Fixed System**
 - Limited fault analysis
- **Virus Protection**
 - 35 year legacy
- **Computational Speed**
 - CPU does all the work
- **Software**
 - The Standard

Multi Domain

- **Reconfigurable System**
 - Component level analysis
- **Virus Protection**
 - Disjoint domains
 - Reconfigurable system
- **Computational Speed**
 - Overhead on separate RISC
- **Software**
 - No change / instruction sets
 - Updates protection

Multi-Domain Architecture

Q&A

