SAND2021-15240C

Sandia National Laboratories

Exceptional service in the national interest

# From naïve to smart: leveraging offloaded capabilities to enable intelligent NICs

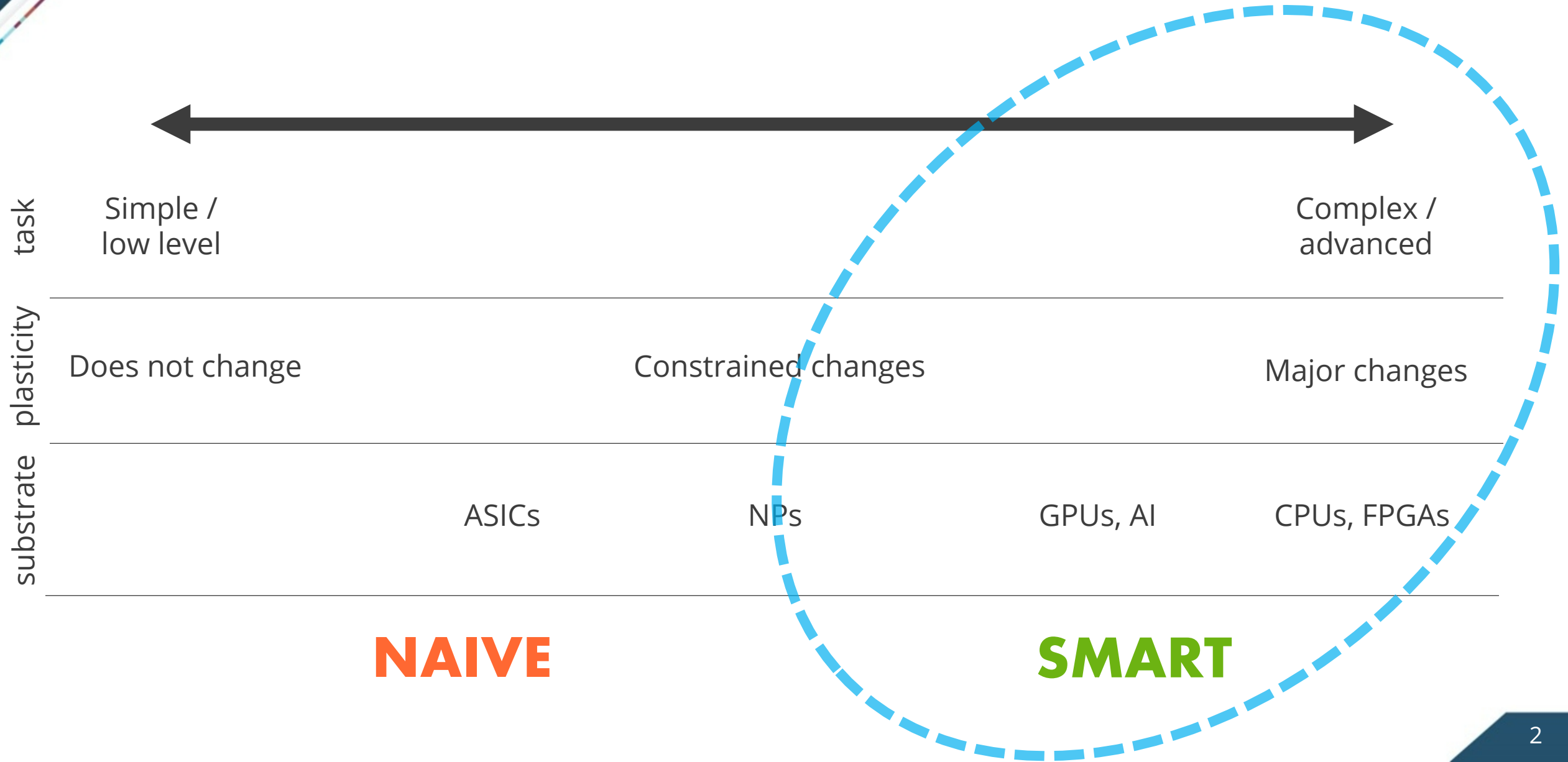
**Whit Schonbein**
wwschon@sandia.gov

2021-12-02

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology and Engineering Solutions of Sandia LLC, a wholly owned subsidiary of Honeywell International Inc. for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International, Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

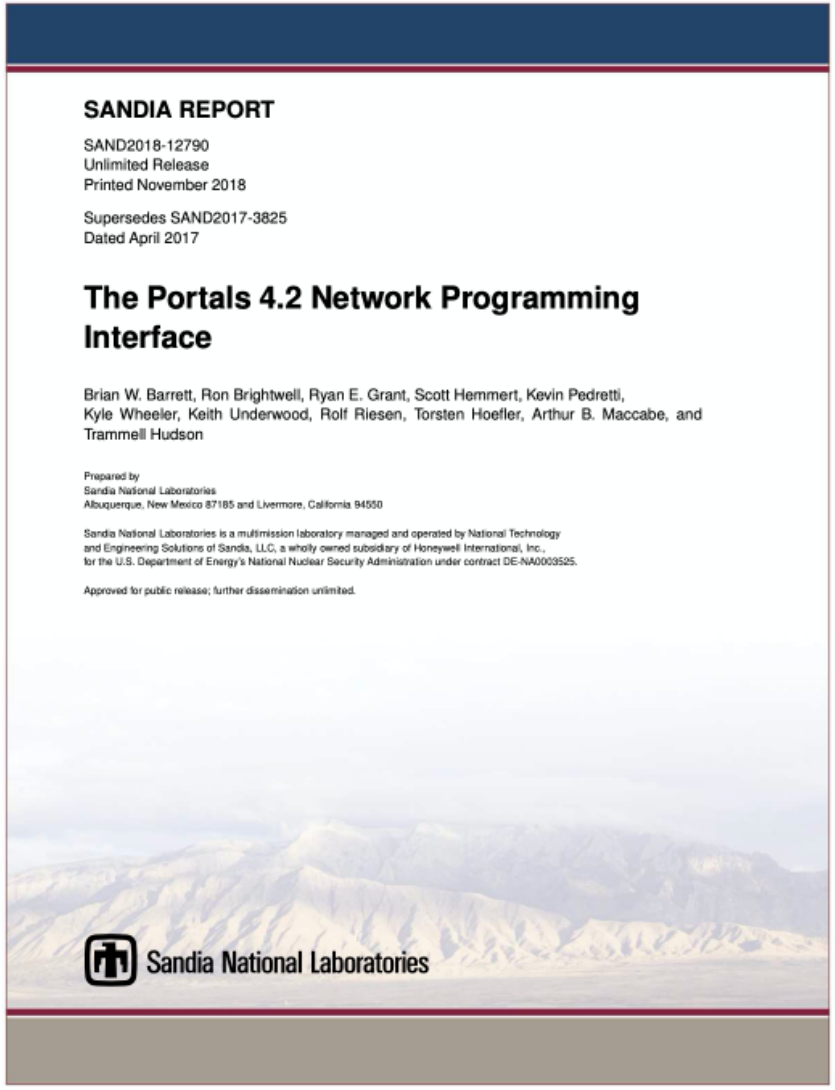
# What is a SmartNIC?



# What is a SmartNIC?

- A NIC that can be configured to perform arbitrary tasks.
- Coordination of heterogeneous task-specific accelerators (GPUs, AI engines, etc.)

# Portals Network API



SANDIA REPORT

SAND2018-12790
Unlimited Release
Printed November 2018

Supersedes SAND2017-3825
Dated April 2017

**The Portals 4.2 Network Programming Interface**

Brian W. Barrett, Ron Brightwell, Ryan E. Grant, Scott Hemmert, Kevin Pedretti, Kyle Wheeler, Keith Underwood, Rolf Riesen, Torsten Hoefler, Arthur B. Maccabe, and Trammell Hudson

Prepared by
Sandia National Laboratories
Albuquerque, New Mexico 87185 and Livermore, California 94550

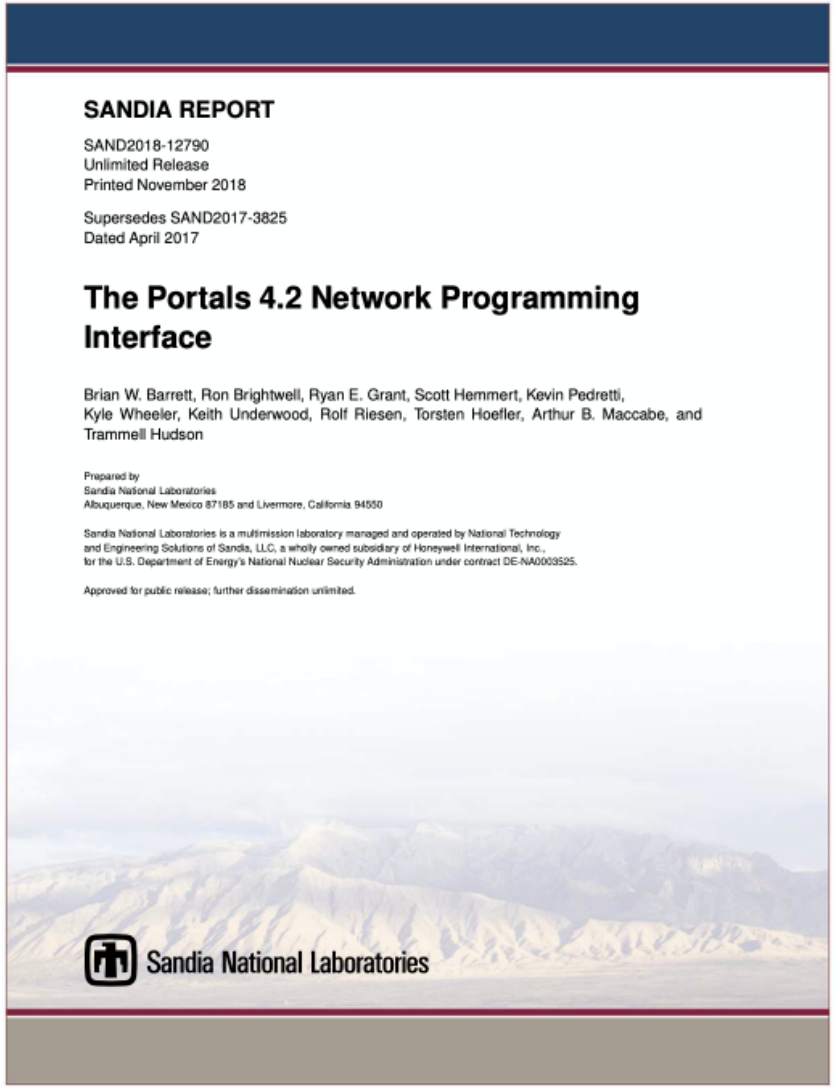
Sandia National Laboratories is a multimission laboratory managed and operated by National Technology and Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International, Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

Approved for public release; further dissemination unlimited.

Sandia National Laboratories

- Network programming API
- Hardware oriented

# Portals Network API



SANDIA REPORT

SAND2018-12790
Unlimited Release
Printed November 2018

Supersedes SAND2017-3825
Dated April 2017

**The Portals 4.2 Network Programming Interface**

Brian W. Barrett, Ron Brightwell, Ryan E. Grant, Scott Hemmert, Kevin Pedretti, Kyle Wheeler, Keith Underwood, Rolf Riesen, Torsten Hoefler, Arthur B. Maccabe, and Trammell Hudson

Prepared by
Sandia National Laboratories
Albuquerque, New Mexico 87185 and Livermore, California 94550

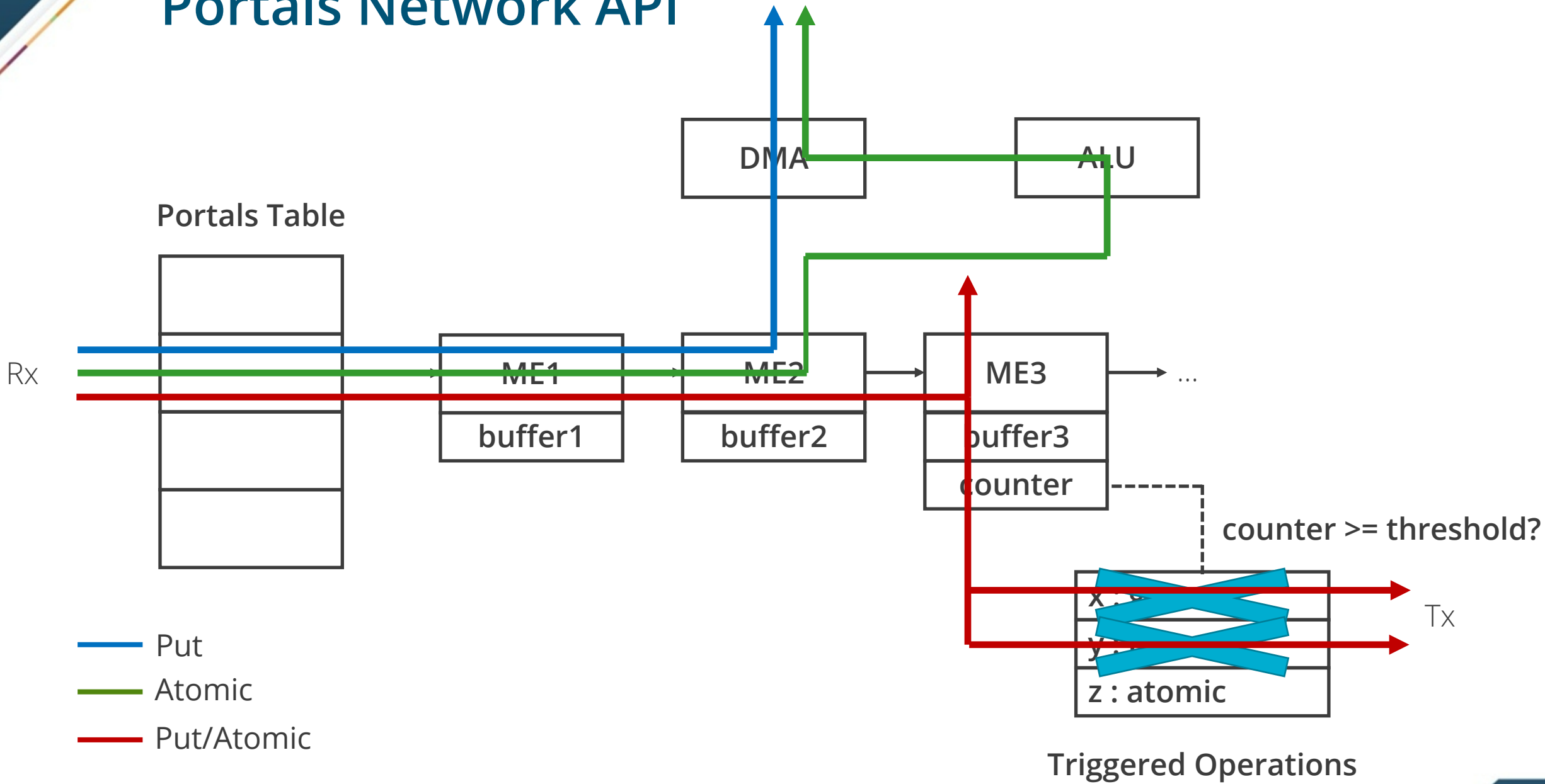
Sandia National Laboratories is a multimission laboratory managed and operated by National Technology and Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International, Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

Approved for public release; further dissemination unlimited.

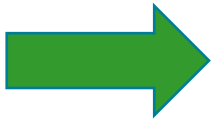
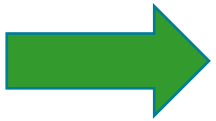
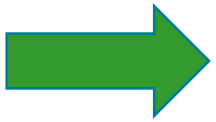
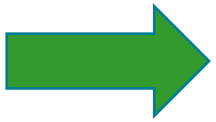
Sandia National Laboratories

- How can a Portals NIC support `intelligent' offloads?

# Portals Network API



# Extending Portals

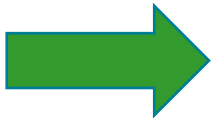
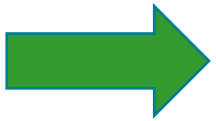
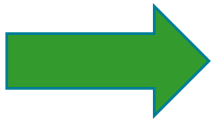
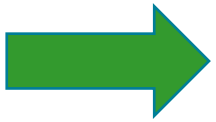
| Current (4.2) | | Proposed |
|---|---|---|
| Target-side resource management: buffers, offsets |  | + ME-specified operations |
| Transient triggered operations |  | + persistent triggered operations |
| Triggering conditions: >= |  | + strict indexing (==) |
| Counter updates: bytes, writes |  | + conditional counter updates |

# Extending Portals

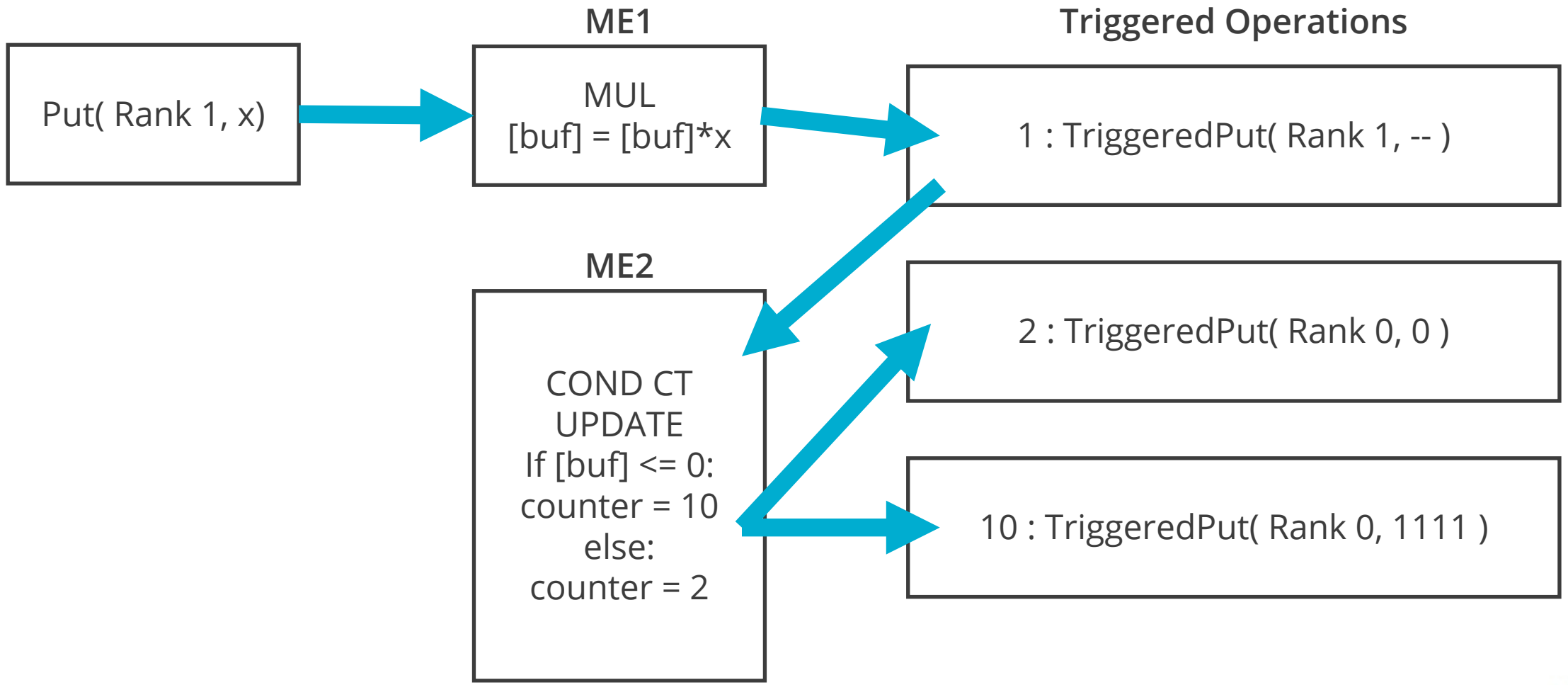
**+ ME-specified operation:**
*counter = (cond ? val1 : val2)*

```
if [buffer] <= 0:
        counter = x
else:
        counter++
```

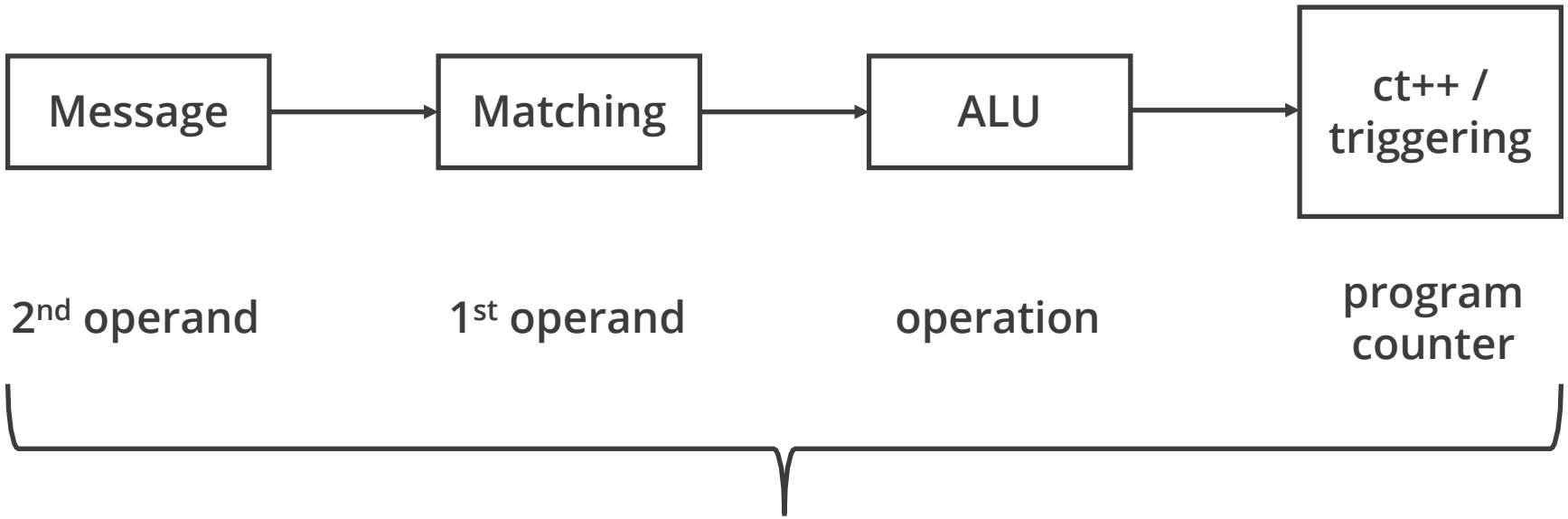
# Extending Portals

| Current (4.2) | | Proposed |
|---|---|---|
| Target-side resource management: buffers, offsets |  | + ME-specified operations |
| Transient triggered operations |  | + persistent triggered operations |
| Triggering conditions: >= |  | + strict indexing (==) |
| Counter updates: bytes, writes |  | + conditional counter updates |

# Extending Portals



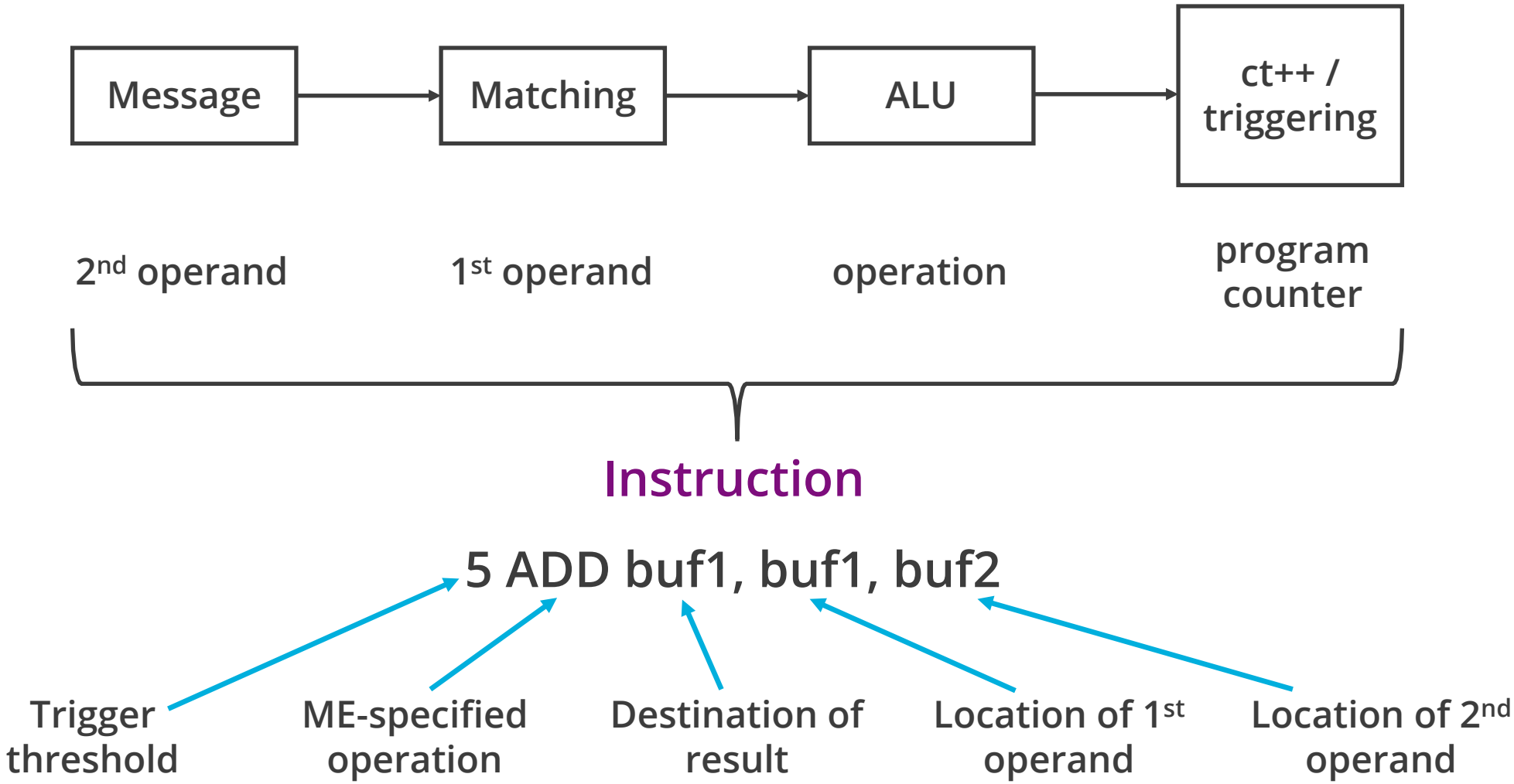
# Enabling Intelligence




**Program: Sequence of instructions sharing the same counter**

**Turing Equivalent**

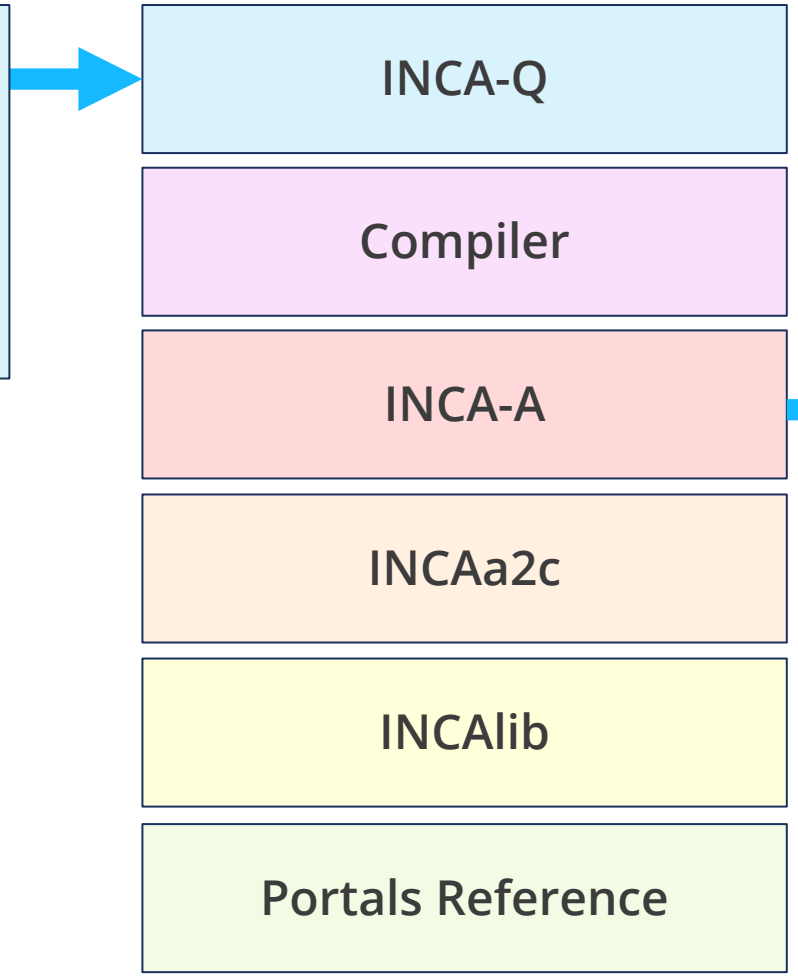
# INCA: In-Network Compute Assistance

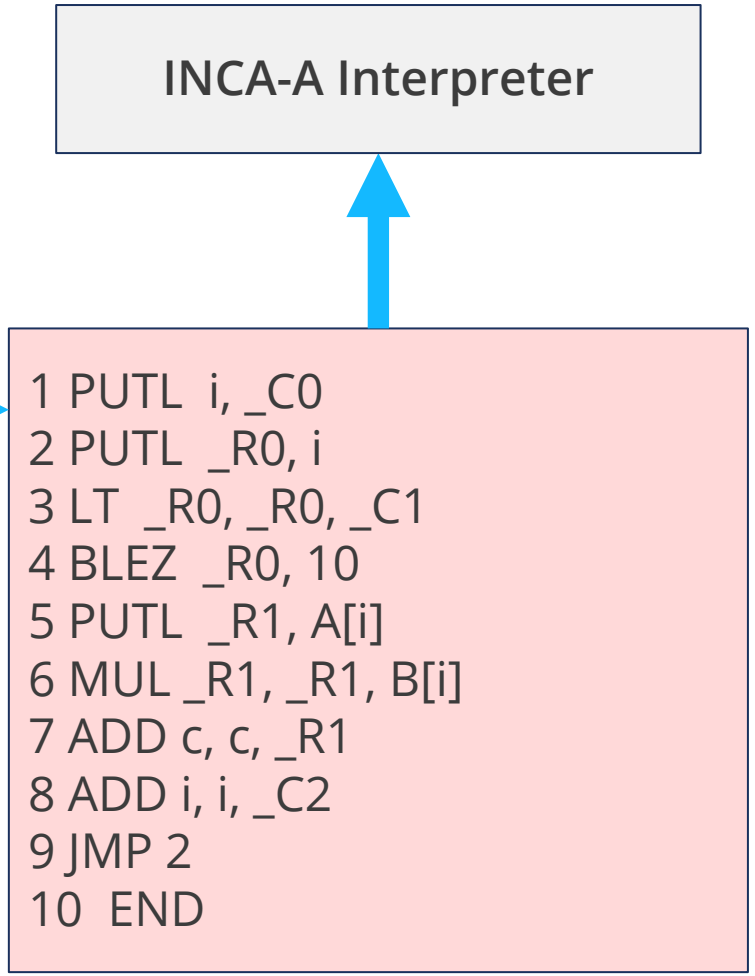


# INCA: In-Network Compute Assistance

```
i = 0
while i < 16 do {
    c = c + (A[i] * B[i])
    i = i + 1
}
end
```

Dot product



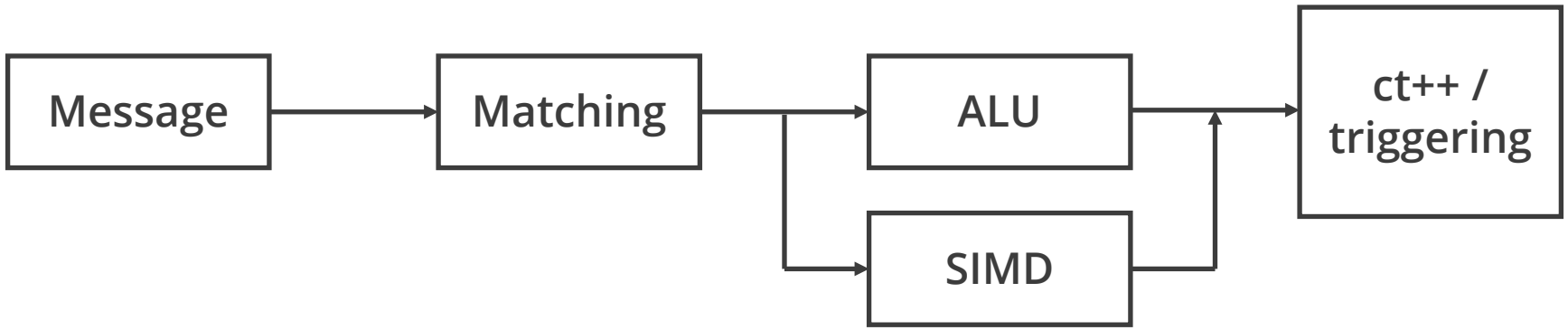
# INCA: In-Network Compute Assistance

| Kernel | usecs |
|---|---|
| convolution | 190.49 |
| dot-product | 31.76 |
| hadamard-product | 31.81 |
| linear-interpolation | 212.85 |
| matrix-multiplication | 1051.20 |
| matrix-transpose | 23.62 |
| unpack | 59.93 |

3.2 GHz Haswell:
139.5 -- 10.5 usecs

400 MMsgs/s, 1ns scratchpad
8KiB payloads

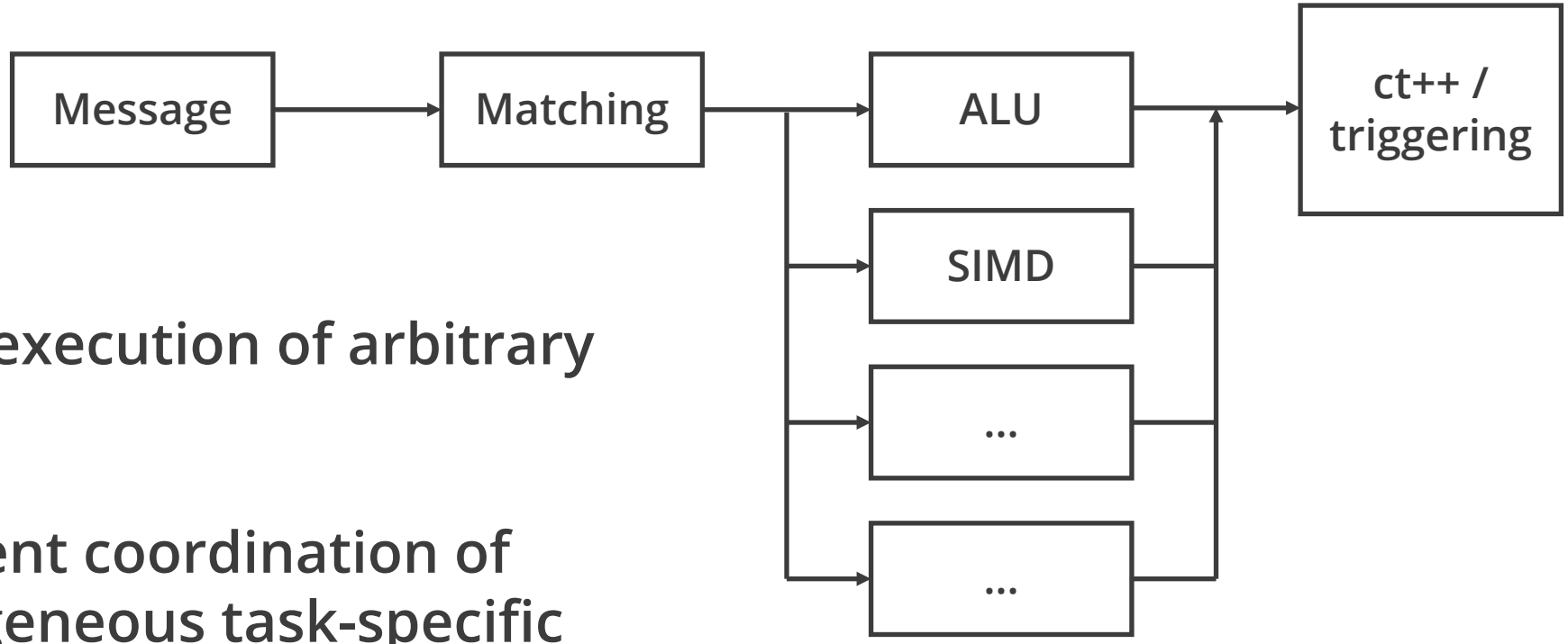
# Enabling Intelligence




2 MULM A[_Z0], A[_Z0], B[_Z0], 256

| Kernel | usecs | usecs |
|---|---|---|
| dot-product | 31.76 | 23.74 |
| hadamard-product-pc | 31.81 | 0.176 |
| matrix-multiplication-p | 1051.20 | 819.61 |
| matrix-multiplication-pc | 1051.20 | 153.60 |

# Enabling Intelligence




- Enable execution of arbitrary tasks
- Intelligent coordination of heterogeneous task-specific accelerators

# Thank You

- Whit Schonbein
  wwschon@sandia.gov

- Portals specification
  https://cs.sandia.gov/Portals/ [BROKEN; but see researchgate]

- Portals reference implementation
  https://github.com/Portals4