

Approximate Computing Is Dead; Long Live Approximate Computing

Adrian Sampson
Cornell

Hardware

Programming

Quality

Domains

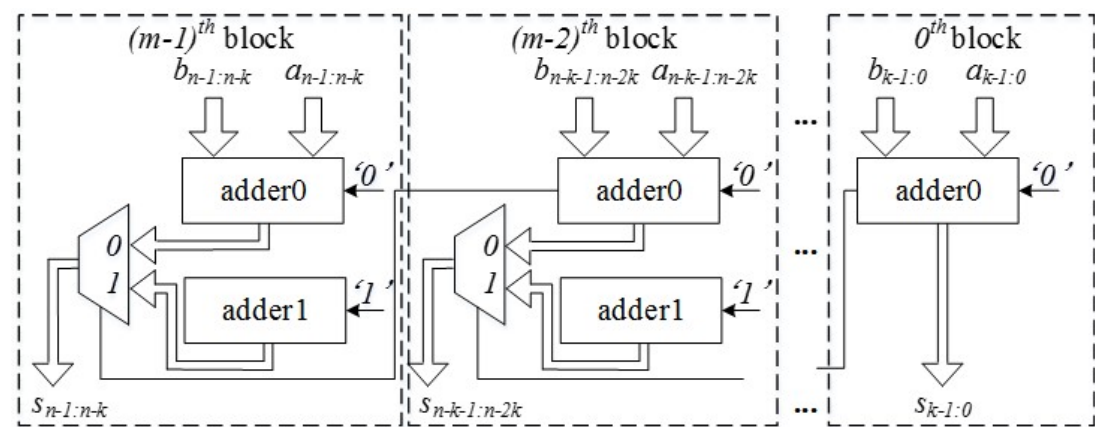
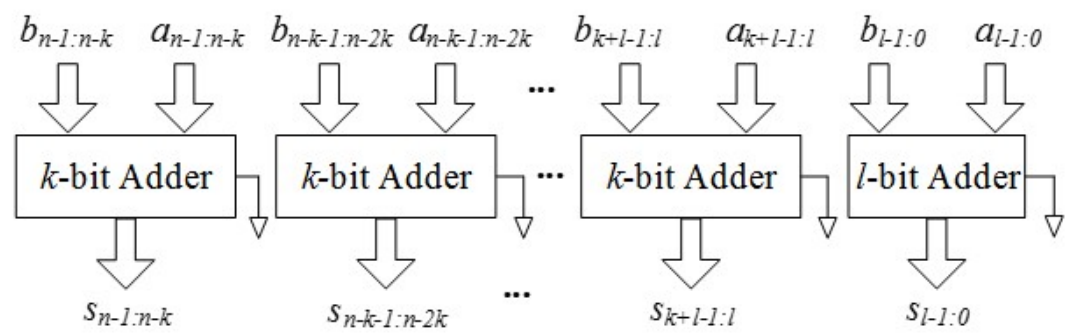
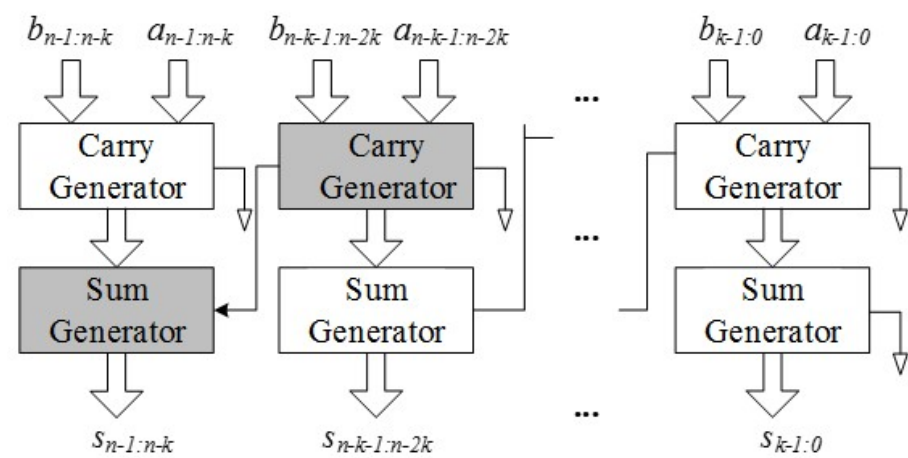
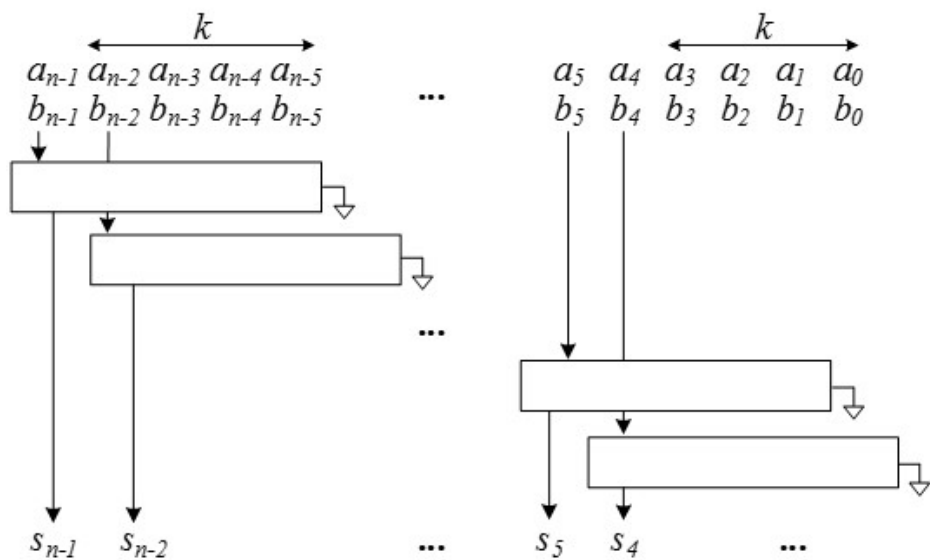
Hardware

Programming

No more approximate functional units.

Quality

Domains



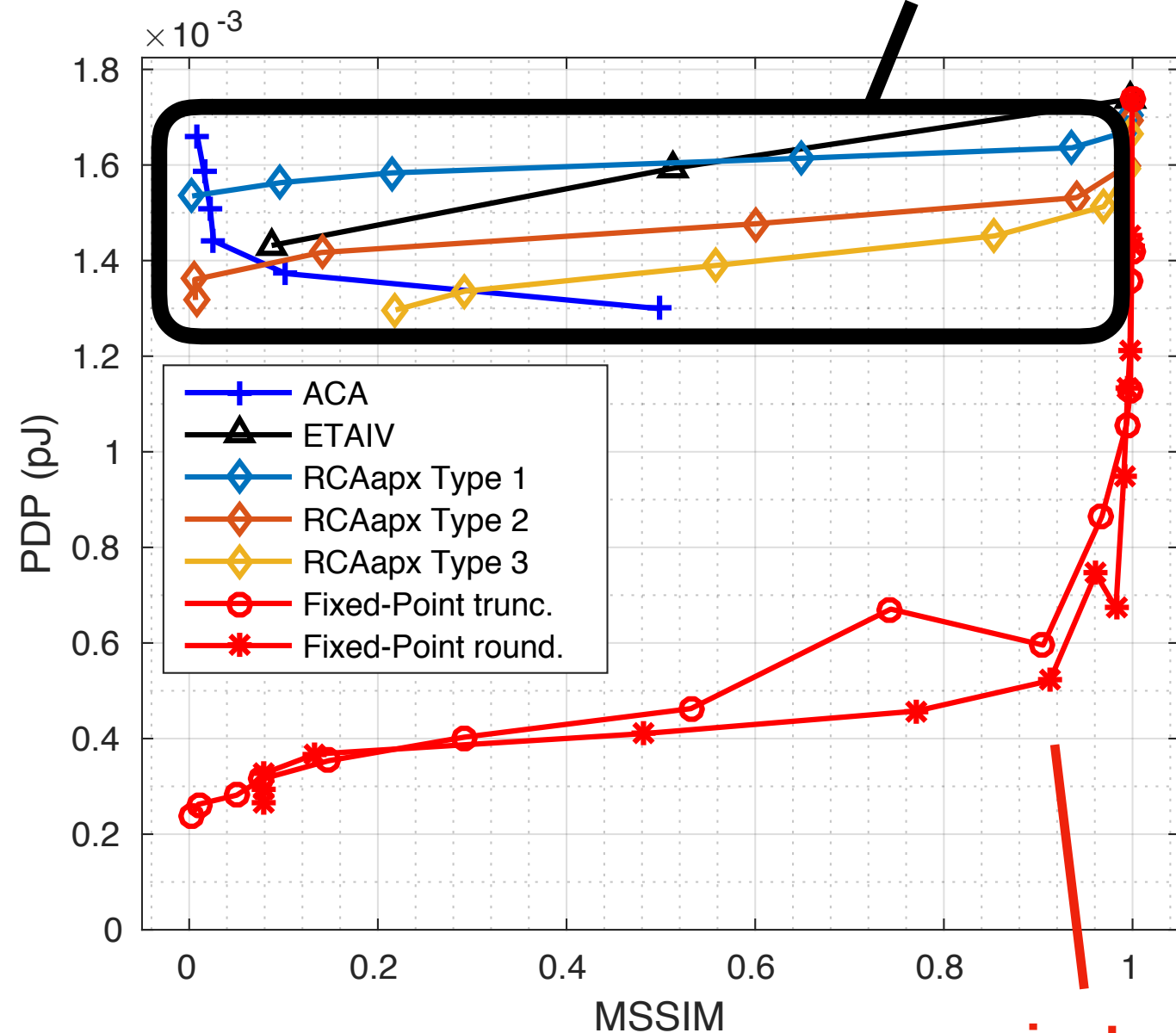
Narrower bit widths are just as good or better

[Barrois et al., DATE 2017]

better efficiency



approximate adders from the literature



just varying the adder width

better accuracy



Hardware

No more approximate functional units.

No more voltage overscaling.

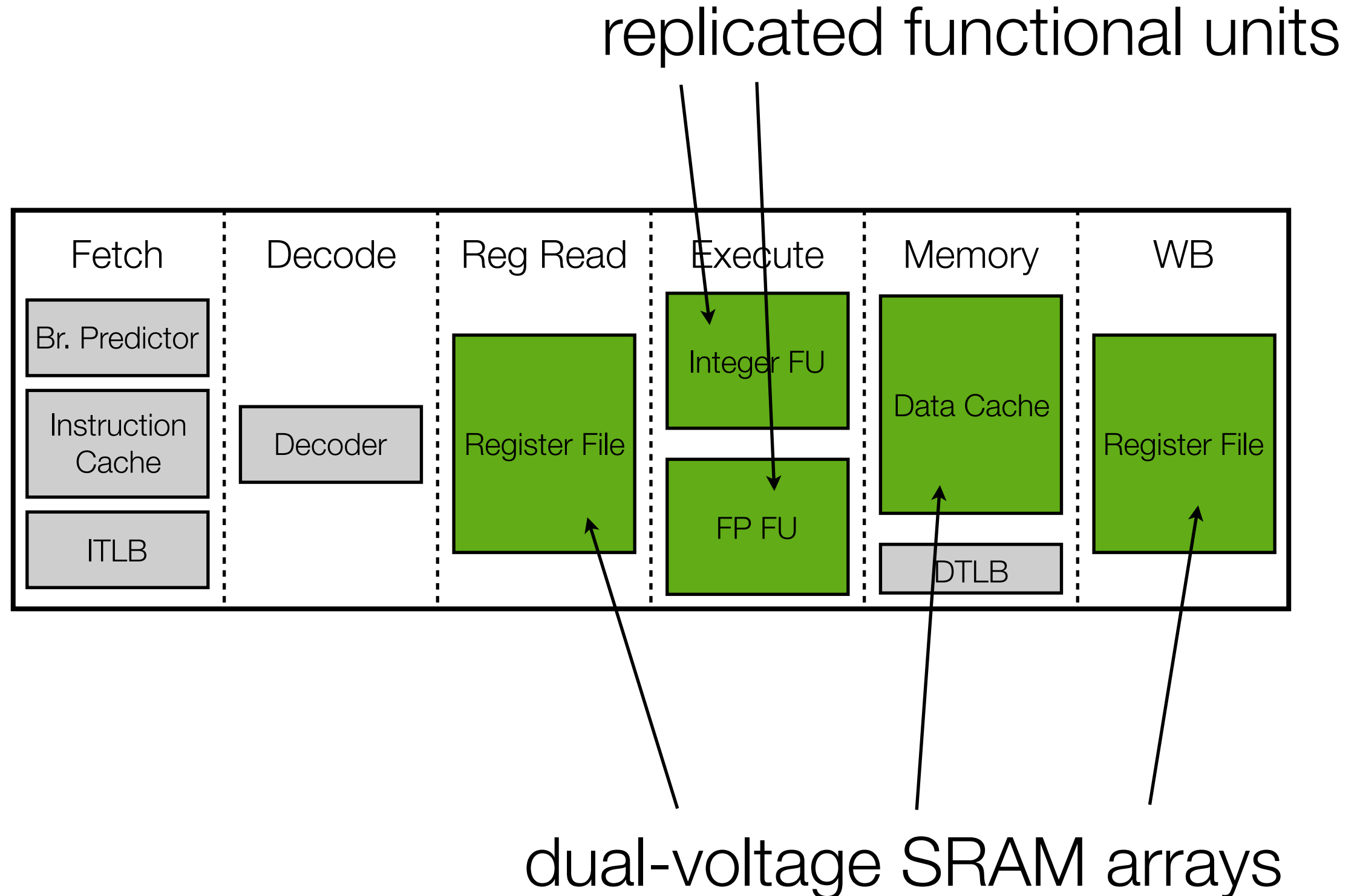
Programming

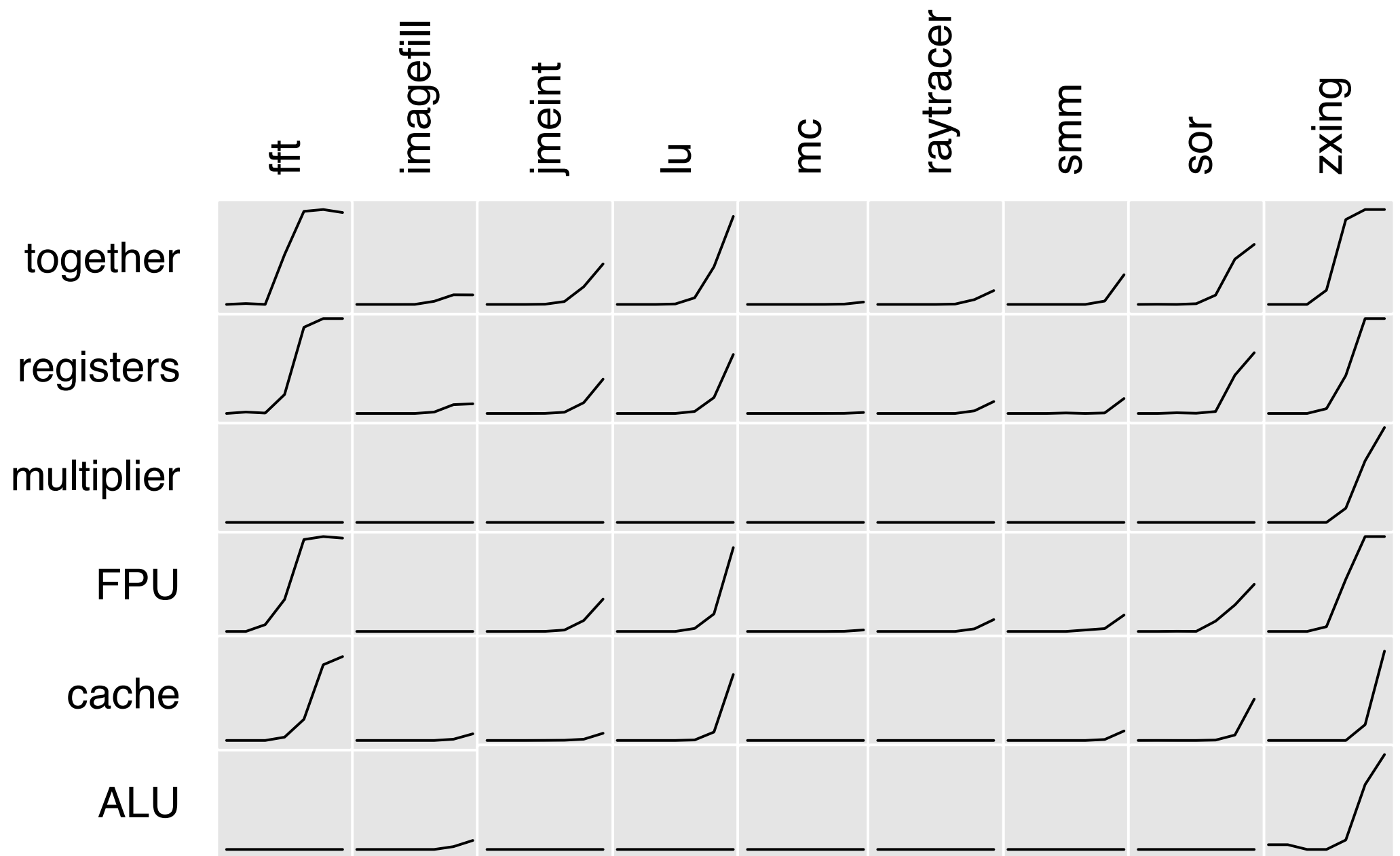
Quality

Domains

Dual-voltage approximate CPU

[ASPLOS 2012]





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In general, no more fine-grained approximate operations.

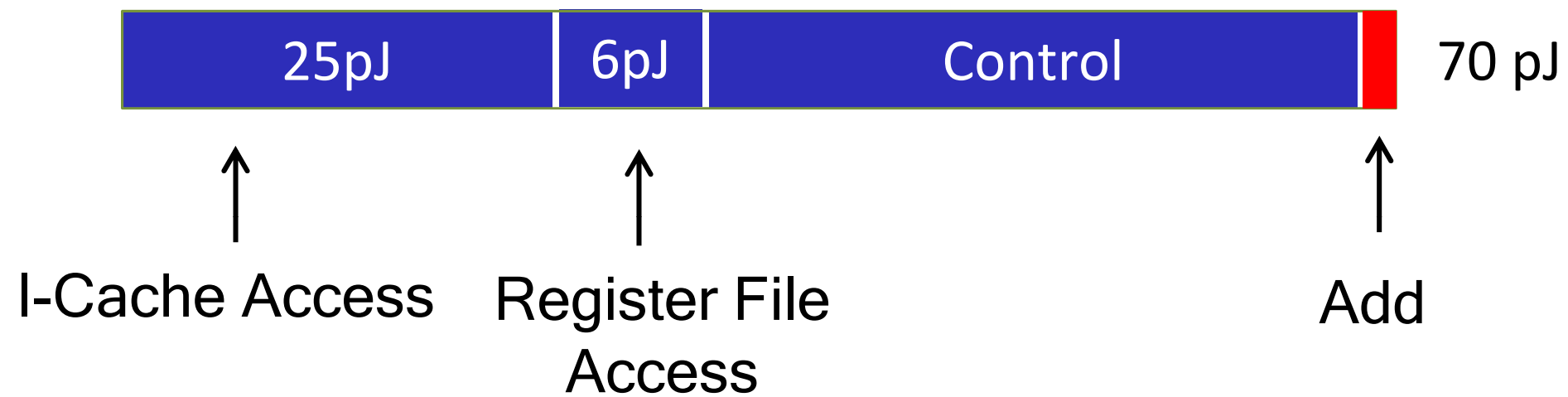
Programming

Quality

Domains

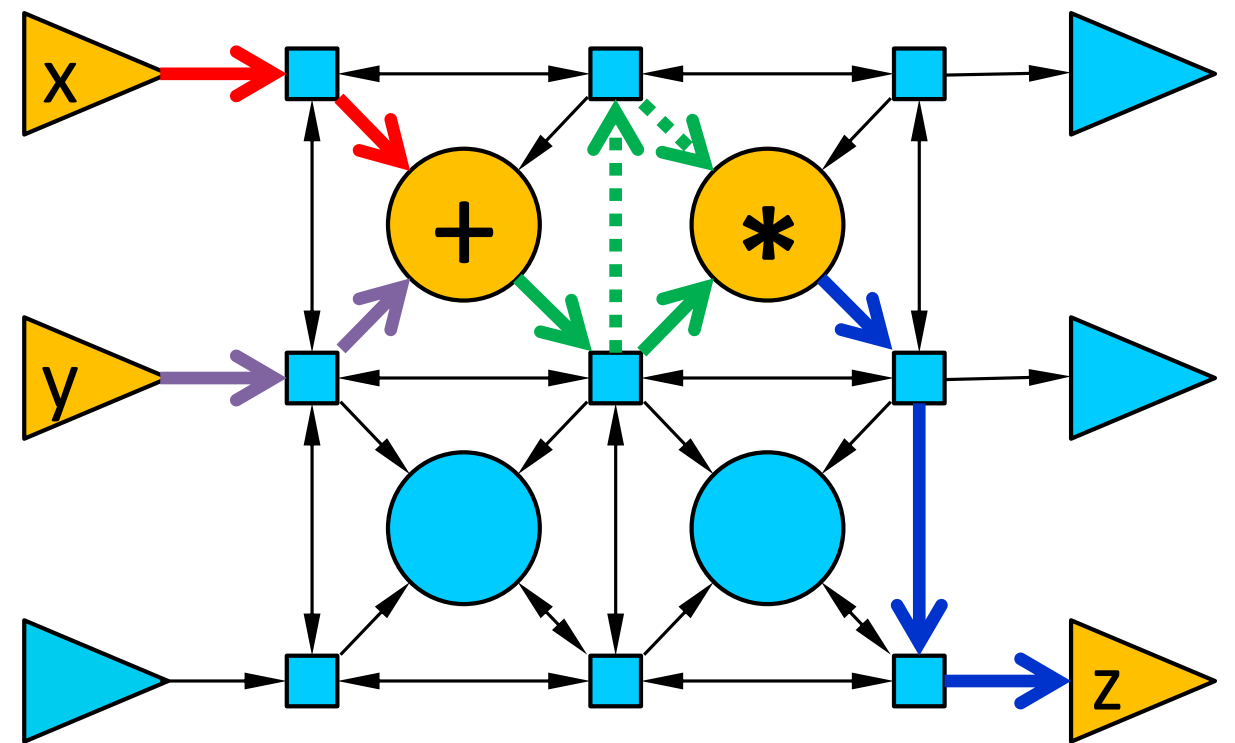
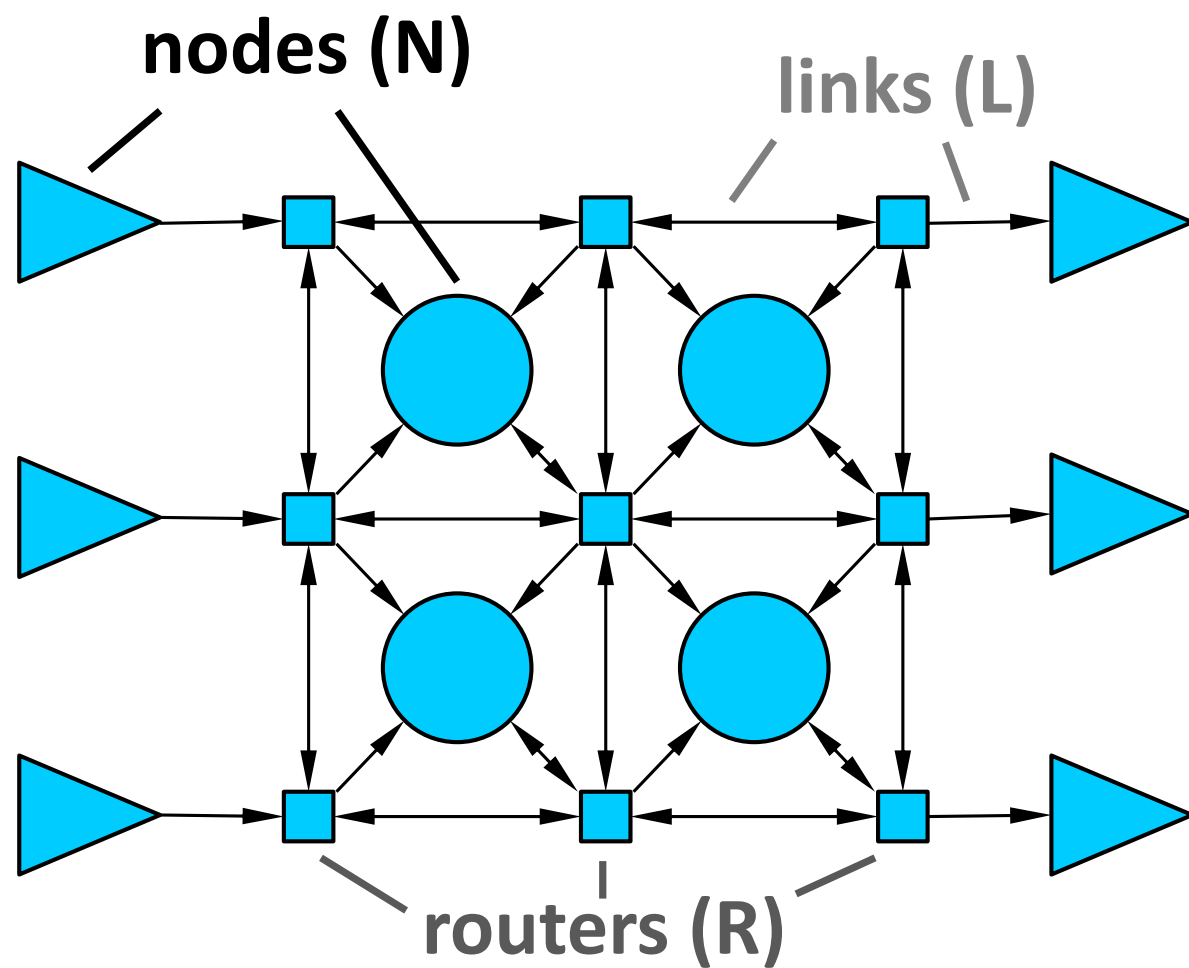
The Horowitz imbalance

a name I made up for this talk
[ISSCC 2014]



Constraint-based programming for spatial architectures

[Nowatzki et al., PLDI 2013]



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No more automatic
approximability analysis.


Domains


EnerJ type qualifiers

[PLDI 2011]

```
@Approx int a = ...;
```

```
int p = ...;
```

 `p = a;`

 `a = p;`

EnerJ type qualifiers

[PLDI 2011]

`@Approx int a = ...;`

`int p = ...;`

**Let's insert these
automatically!**



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No more automatic approximability analysis.

No more generic unsound compiler transformations.

Domains

Loop perforation

[Sidiroglou-Douskos et al., FSE 2011]

```
for (int i = 0; i < max; i++ i += 2) {  
    // whatever  
}
```


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Quality

No more weak statistical guarantees.

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Domains

Traditional guarantee

$\forall x \ f(x)$ is good

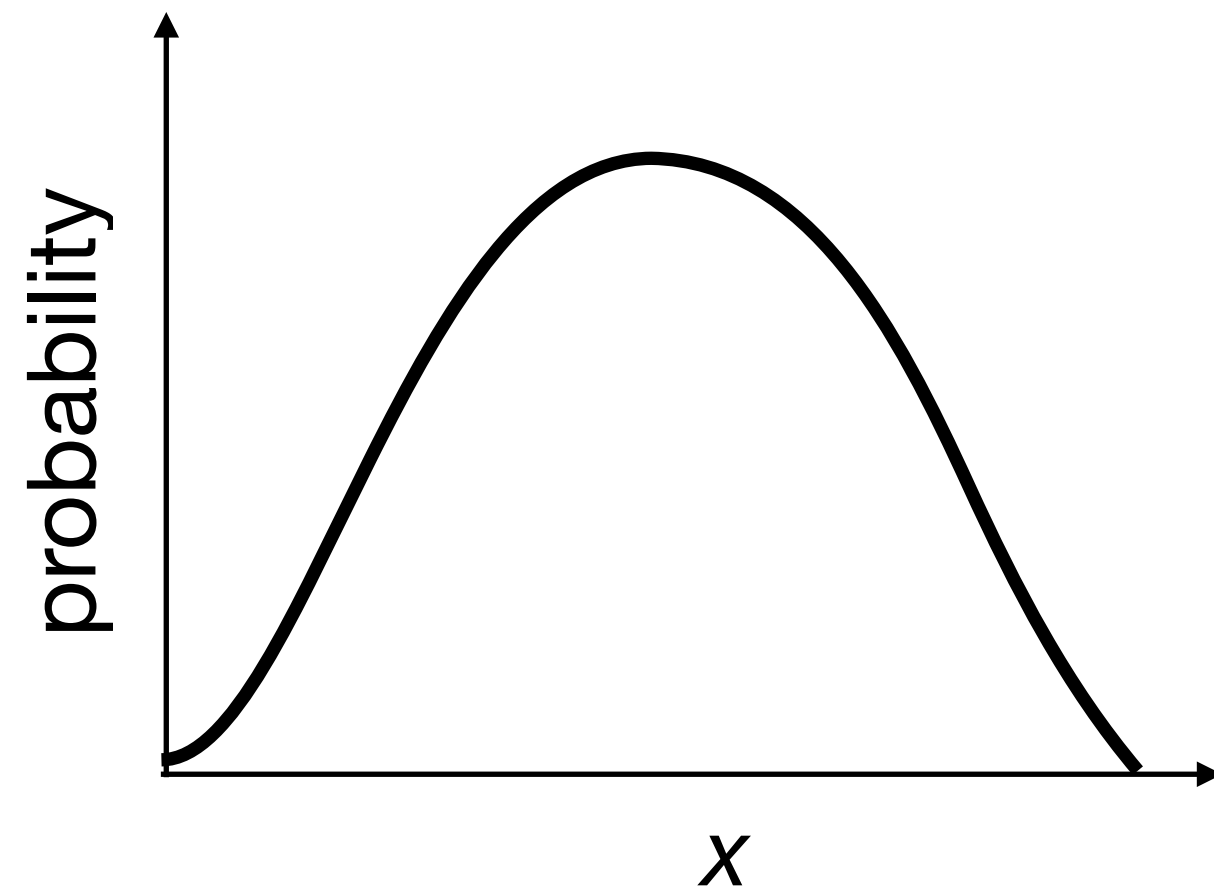
Statistical guarantee

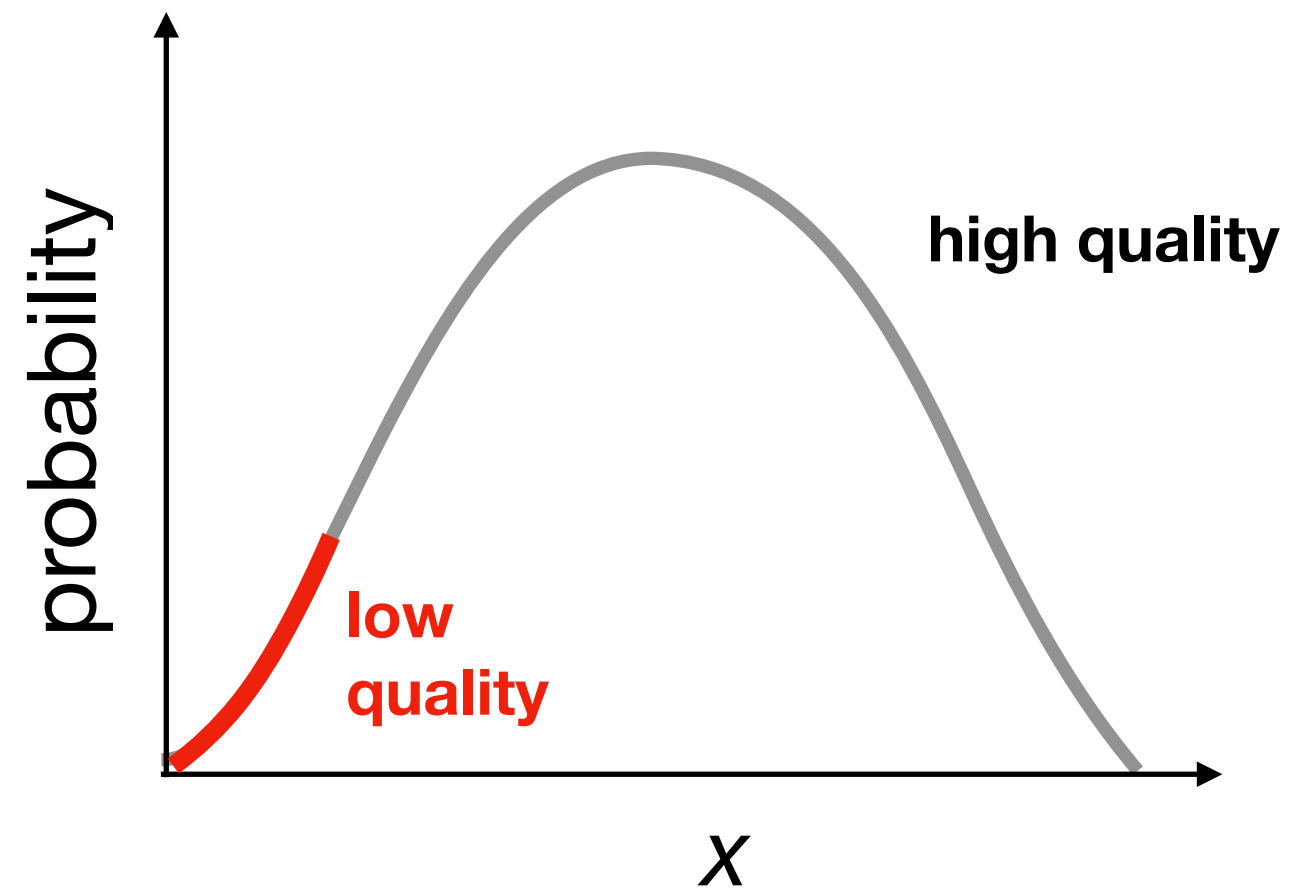
$$\Pr [f(x) \text{ is good}] \geq T$$

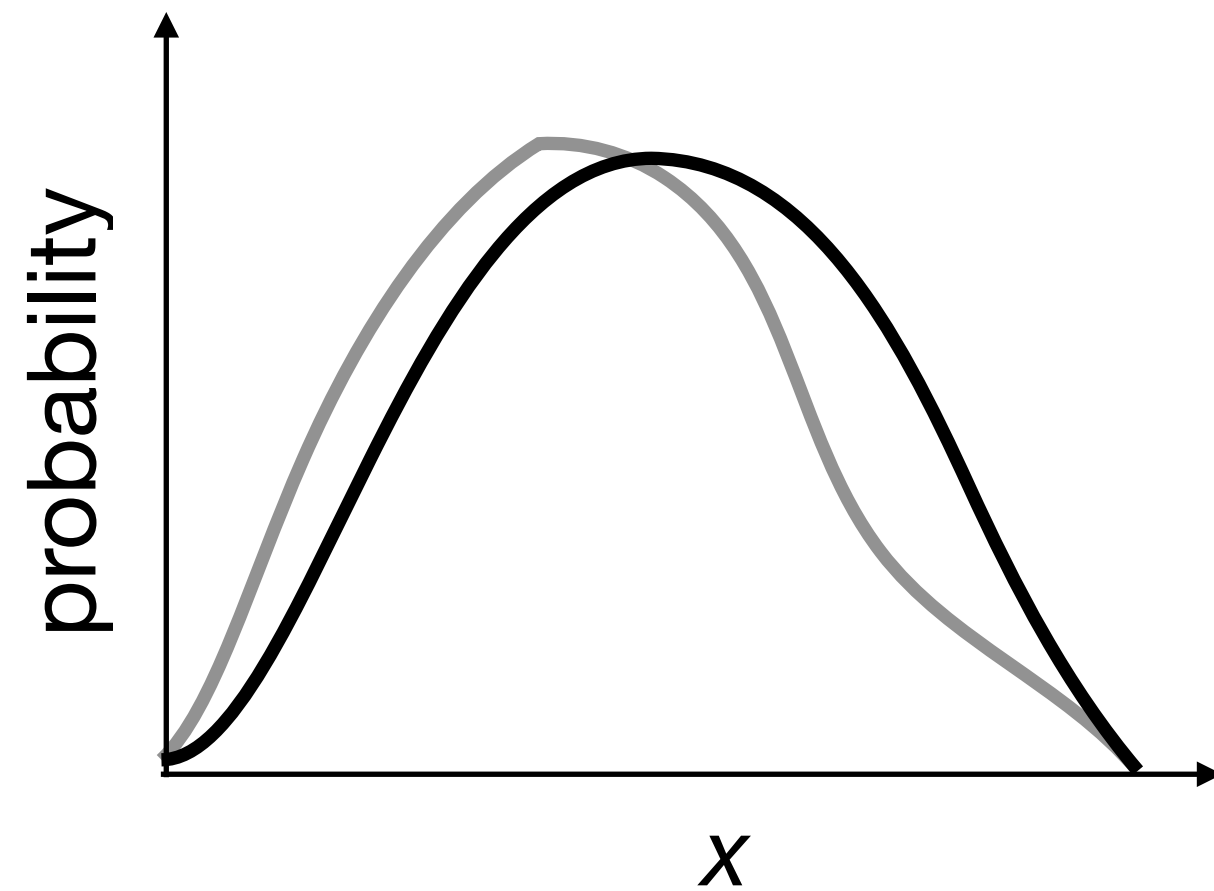
Statistical guarantee, in reality

$$\Pr_{x \sim D} [f(x) \text{ is good}] \geq T$$

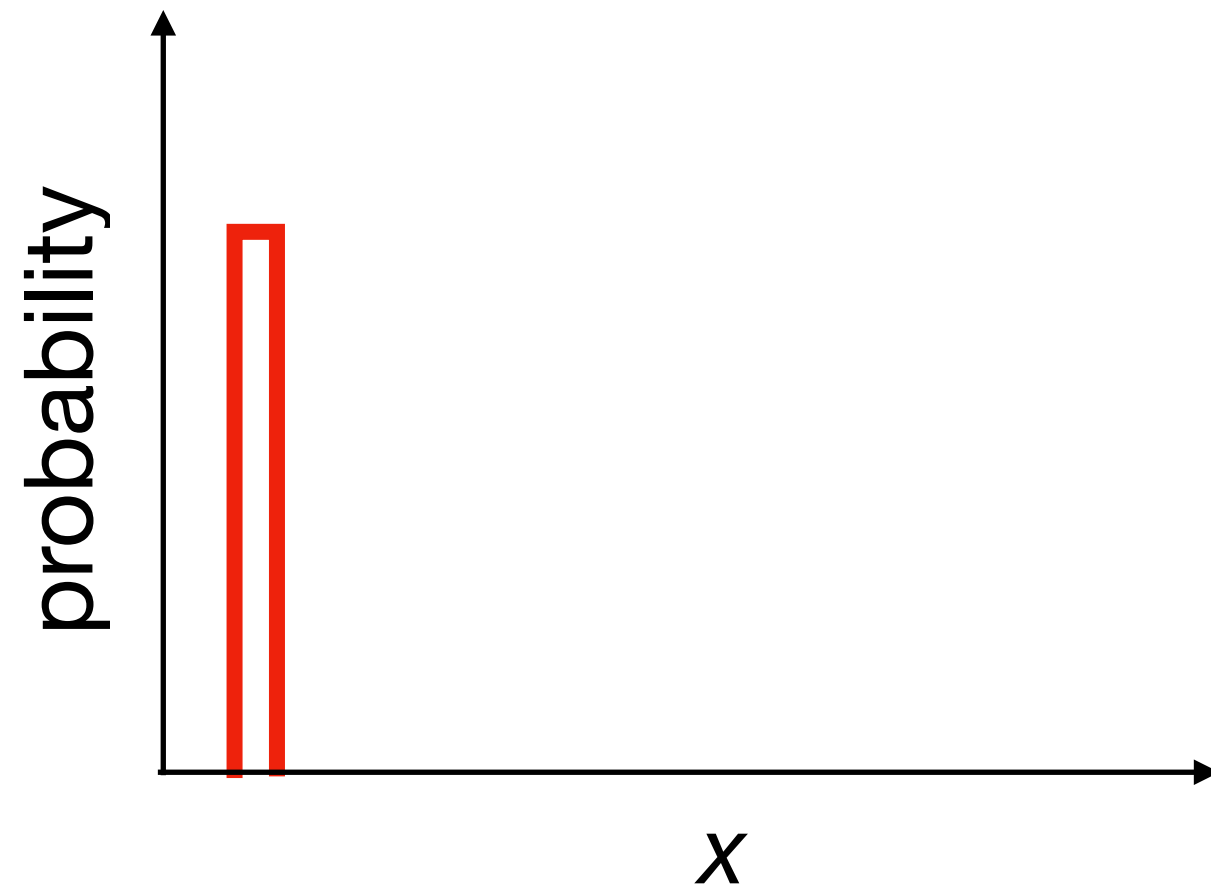
↑
anticipated input distribution







Adversarial distribution



Natural Language for



Bots



Mobile apps



Home automation

Wit not only enables your robot to understand and discover their unforeseen needs.

aws

Menu Products More English My Account Sign Up

Amazon Rekognition

Deep learning-based image recognition
Search, verify, and organize millions of images

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No more sadness about the imperfection of quality metrics.

Application	Description	Error metric
FFT	Scientific kernels from the SciMark2 benchmark	Mean entry difference
SOR		Mean entry difference
MonteCarlo		Normalized difference
SparseMatMult		Mean normalized difference
LU		Mean entry difference
ZXing	Smartphone bar code decoder	1 if incorrect, 0 if correct
jMonkeyEngine	Mobile/desktop game engine	Fraction of correct decisions normalized to 0.5
ImageJ	Raster image manipulation	Mean pixel difference
Raytracer	3D image renderer	Mean pixel difference

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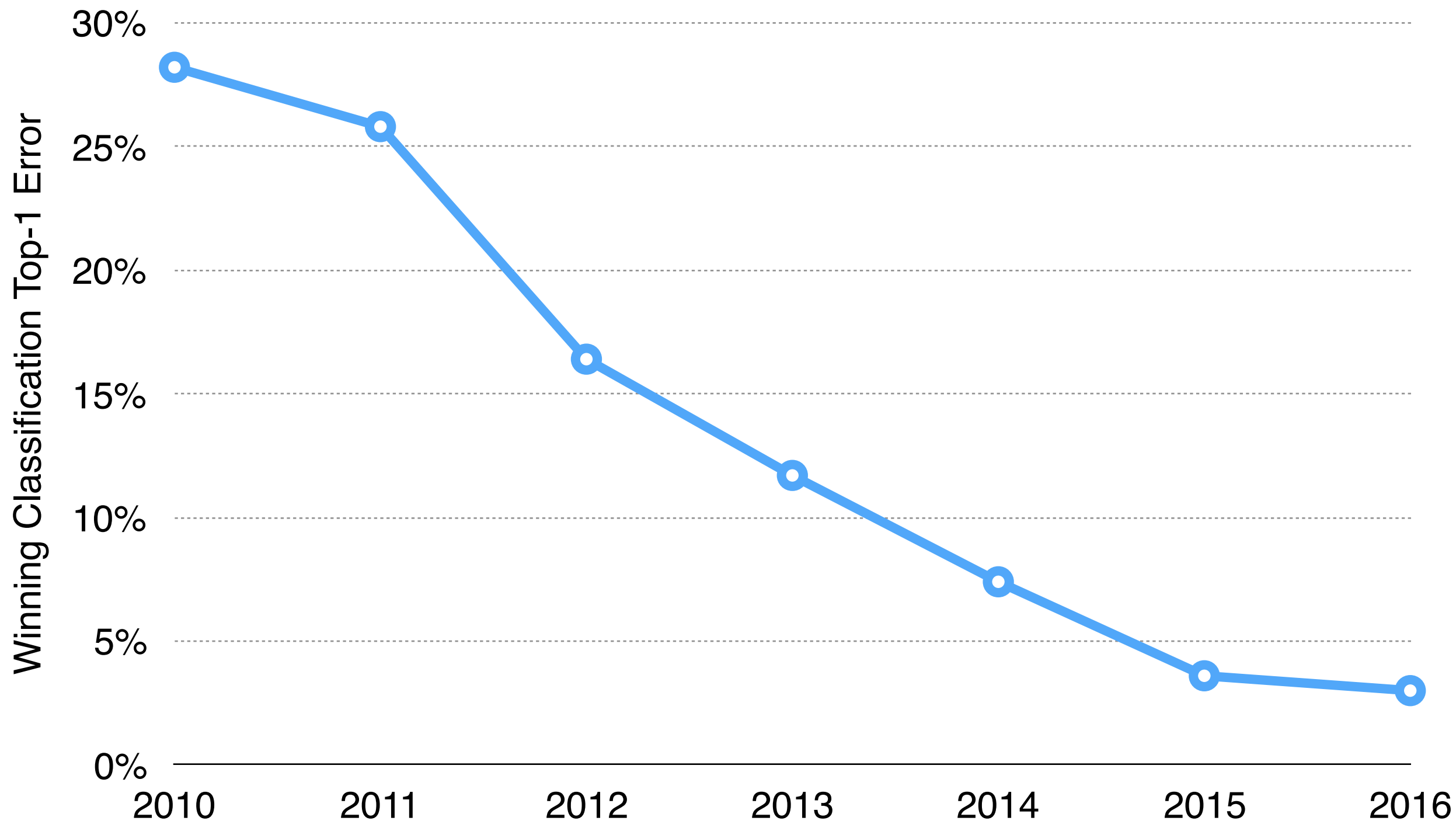
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No more benchmark-oriented research?


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ImageNet annual competition





Real-time graphics








Halo 5 Guardians: The Price Of 60fps



DigitalFoundry

189,987

 Add to

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 3,986  317

262,794

Published on Oct 26, 2015

343 Industries promised us a 60fps experience for Halo 5: Guardians and the developer has delivered. But

<https://youtu.be/-gQMulb6T2o>

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Notes and links:

<http://www.cs.cornell.edu/~asampson/blog/closedproblems.html>