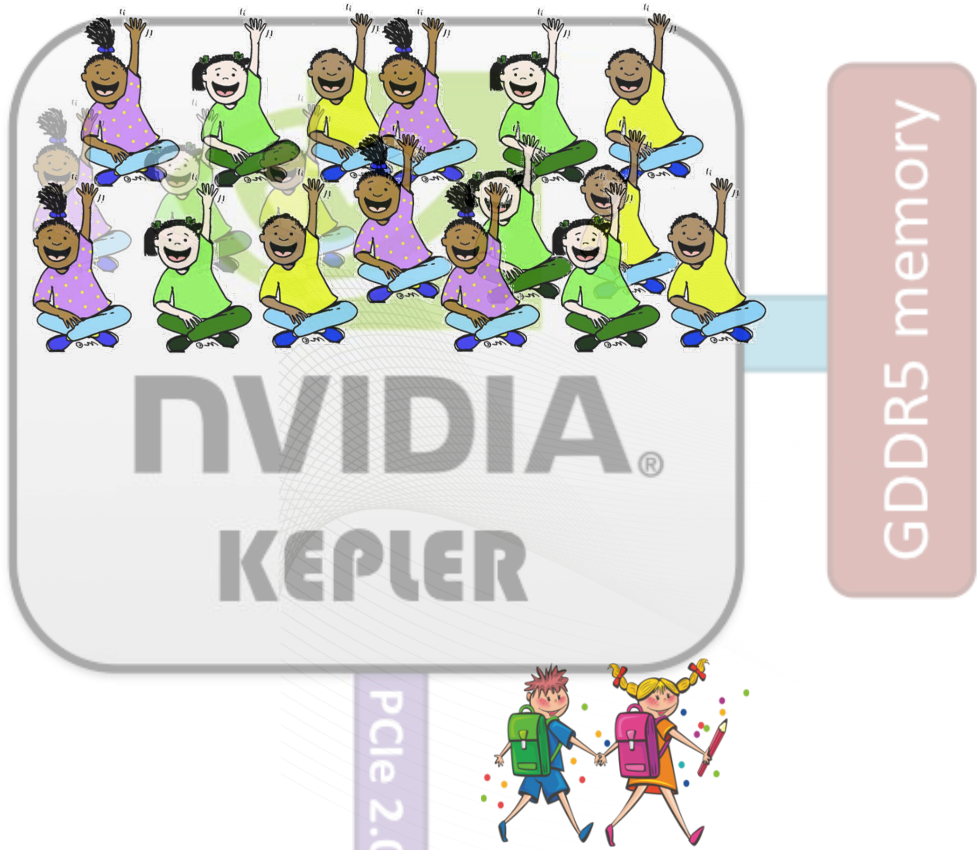
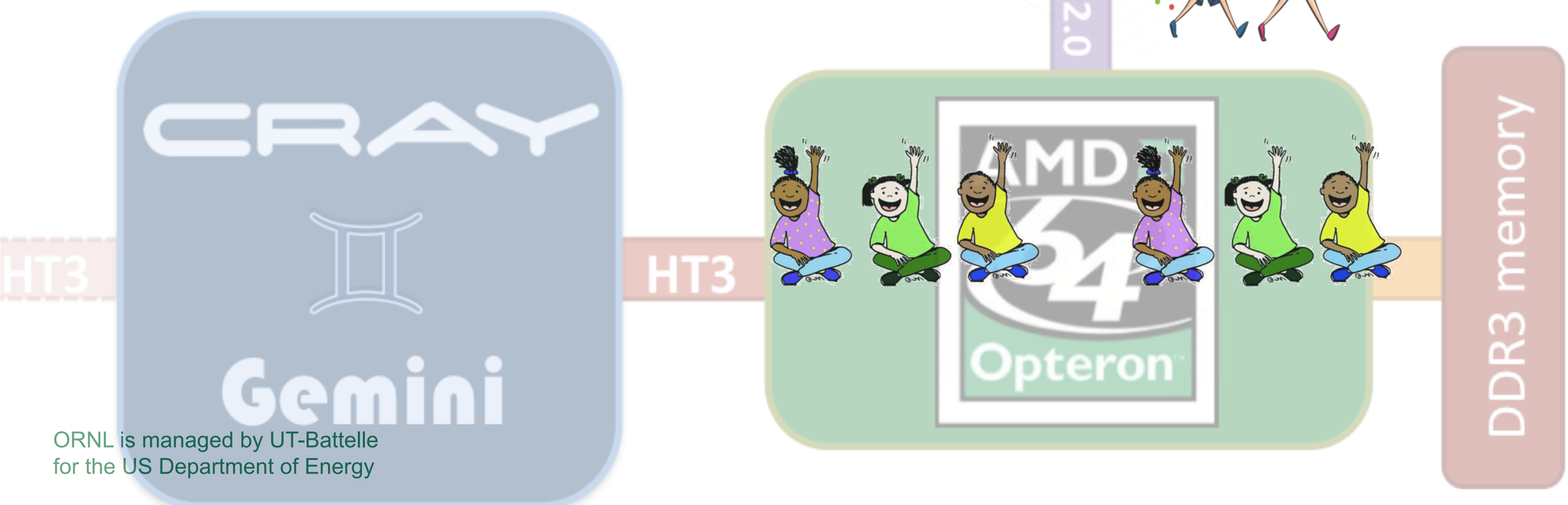
Human
Supercomputer

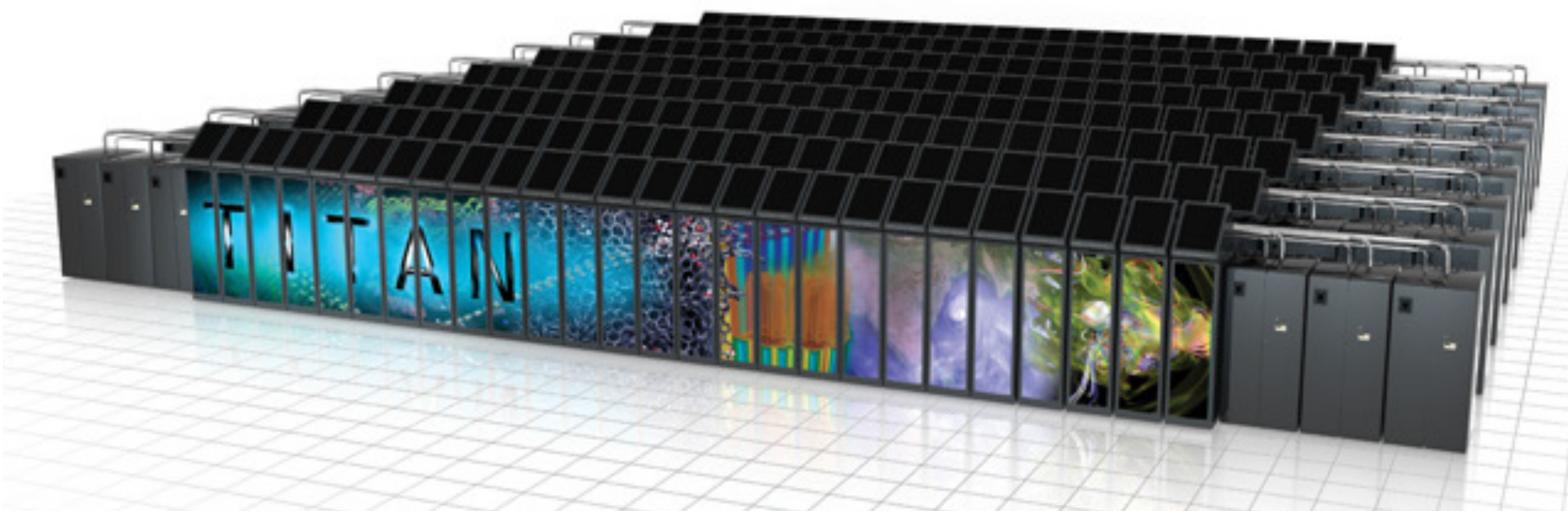
Massively
Parallel





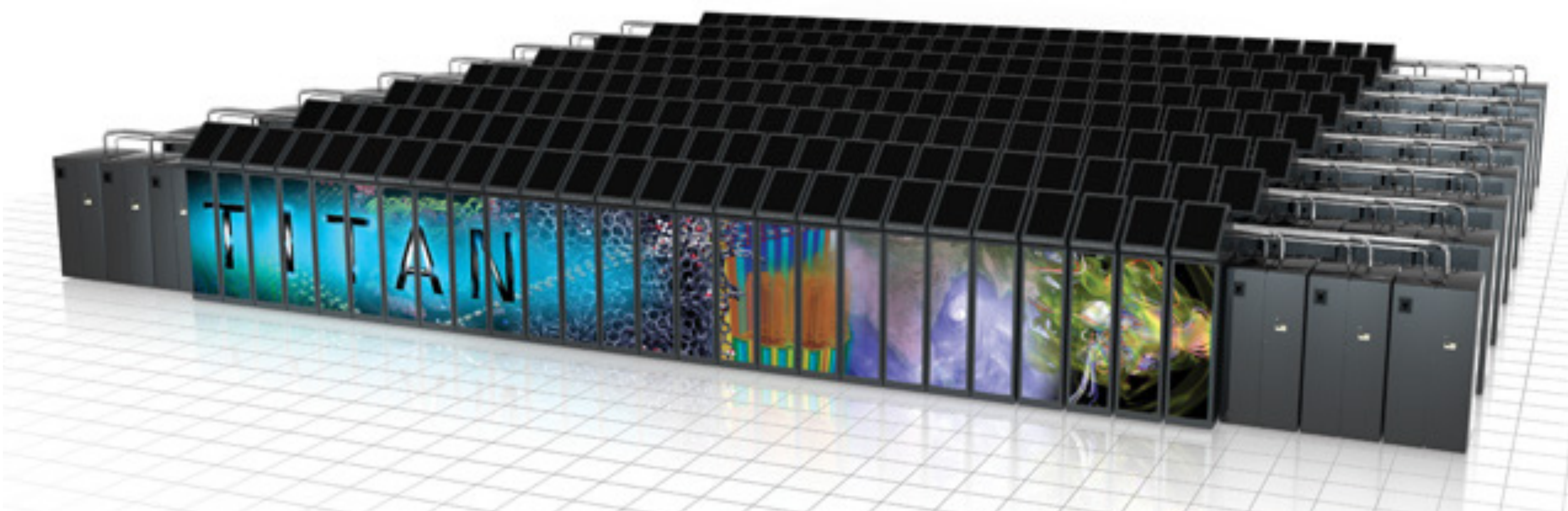
Parallel Computing

- The Oak Ridge Leadership Computing Facility runs Titan, the most powerful computer for open research in the United States.
- 27 quadrillion calculations per second!
- 18,688 nodes



Parallel Computing

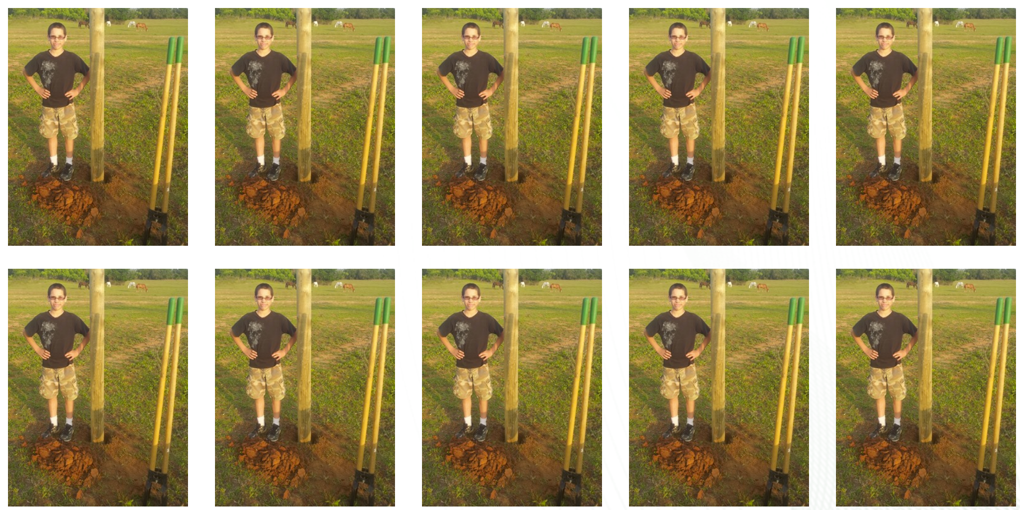
- Parallel computing — Multiple processors are split up and specially adapted to work on different parts of the same task at the same time, achieving faster results.



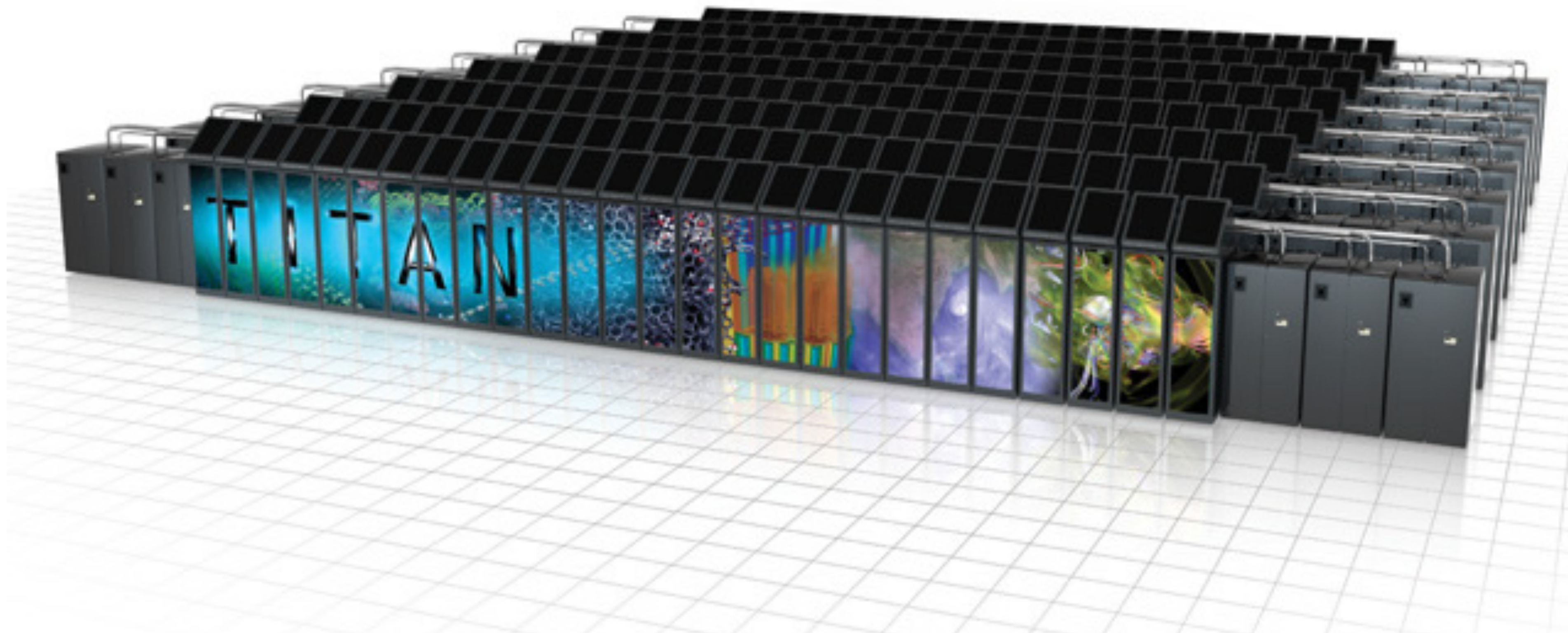
“Split up and Specially Adapted”

- One person can dig a post-hole and install a fence post in 20 minutes.
- If only one person works, it will take days to put in a 60 post fence.
- If 60 people each put in a post, it will take less than an afternoon to put in the same fence.

VS



Like having 20,000 really good laptops working together to help solve a problem!



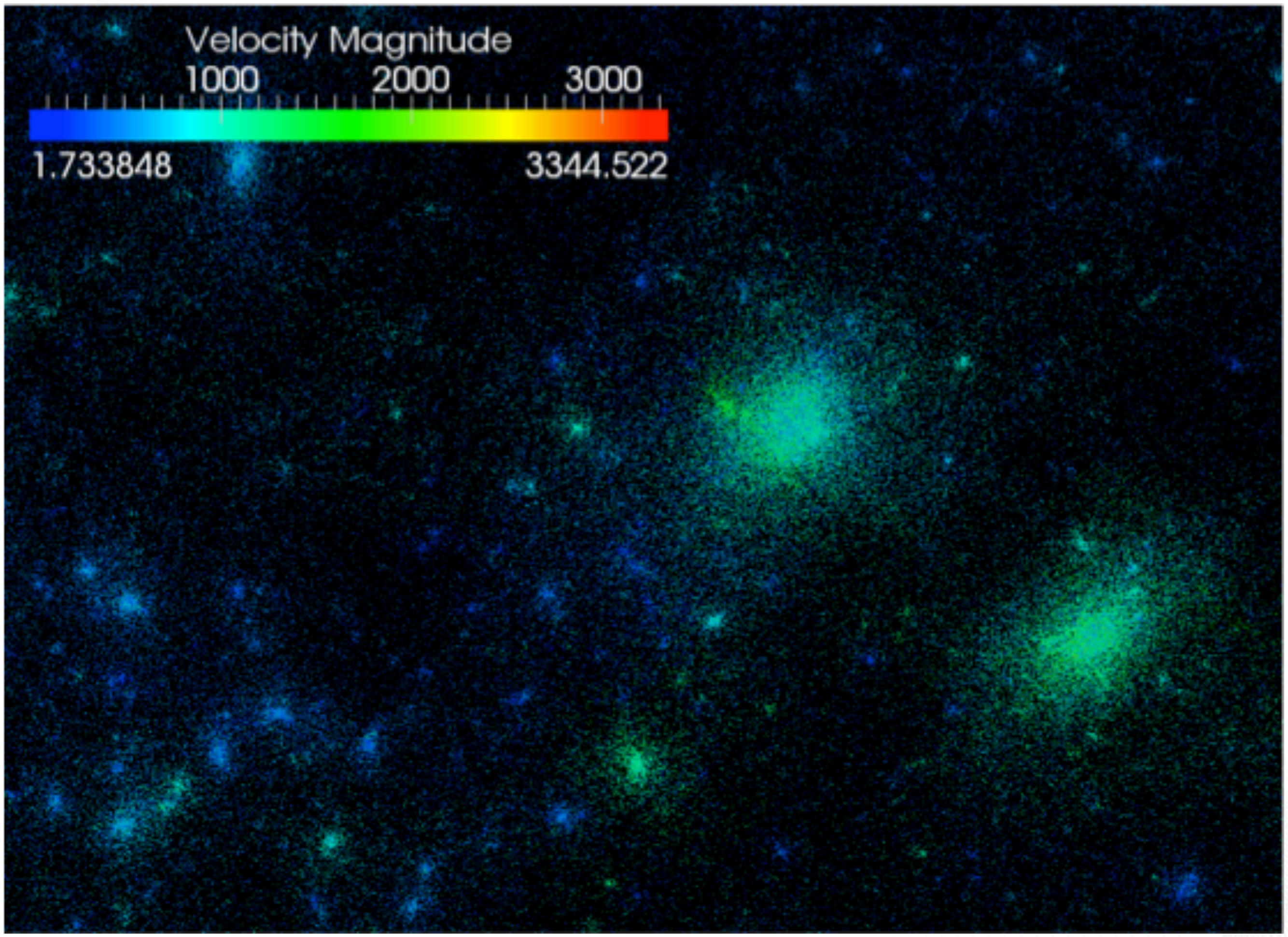
Why Do This?

- You can calculate things you can not do with any other method.

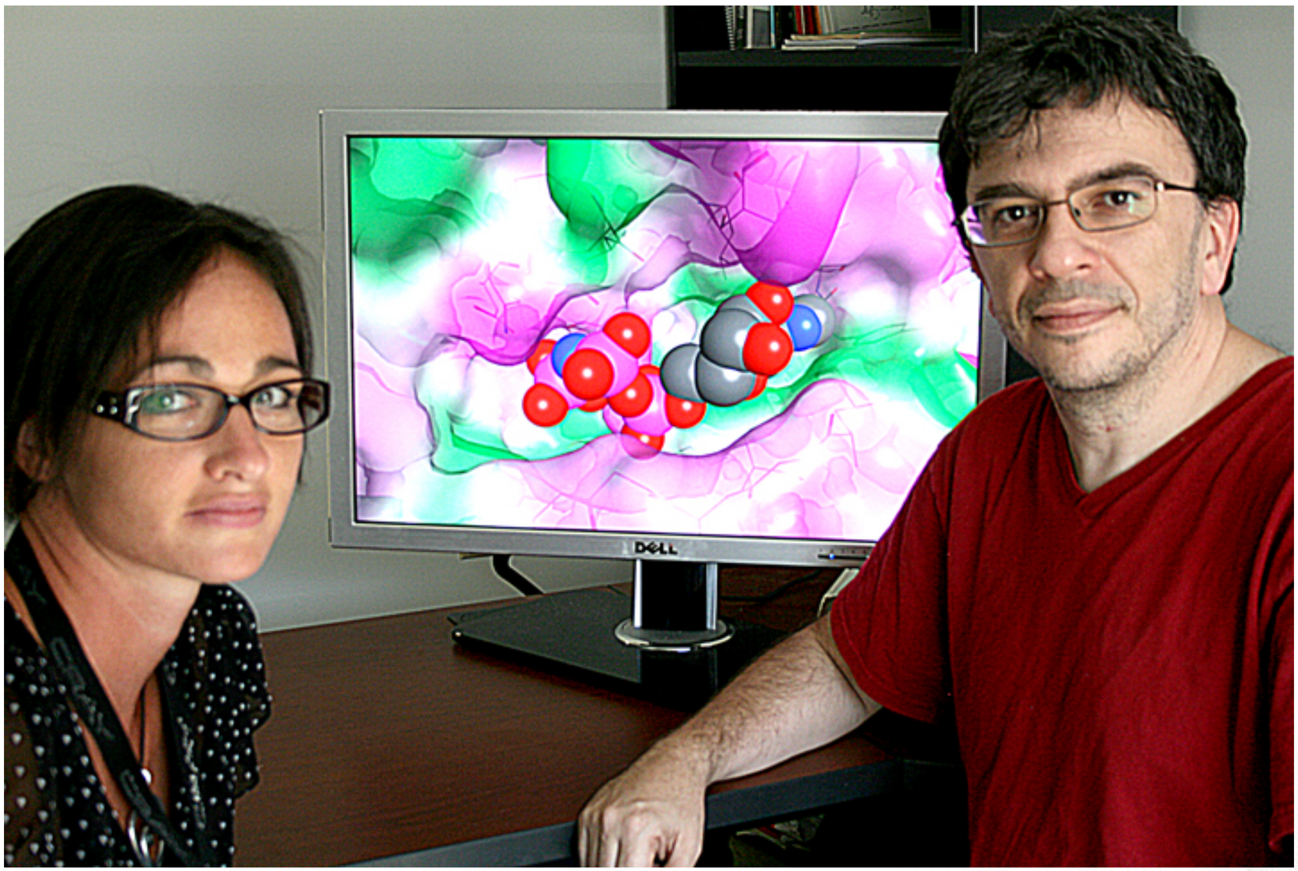
- Solve systems of literally ***1000s*** of equations!

Model Engineering: Smart Truck

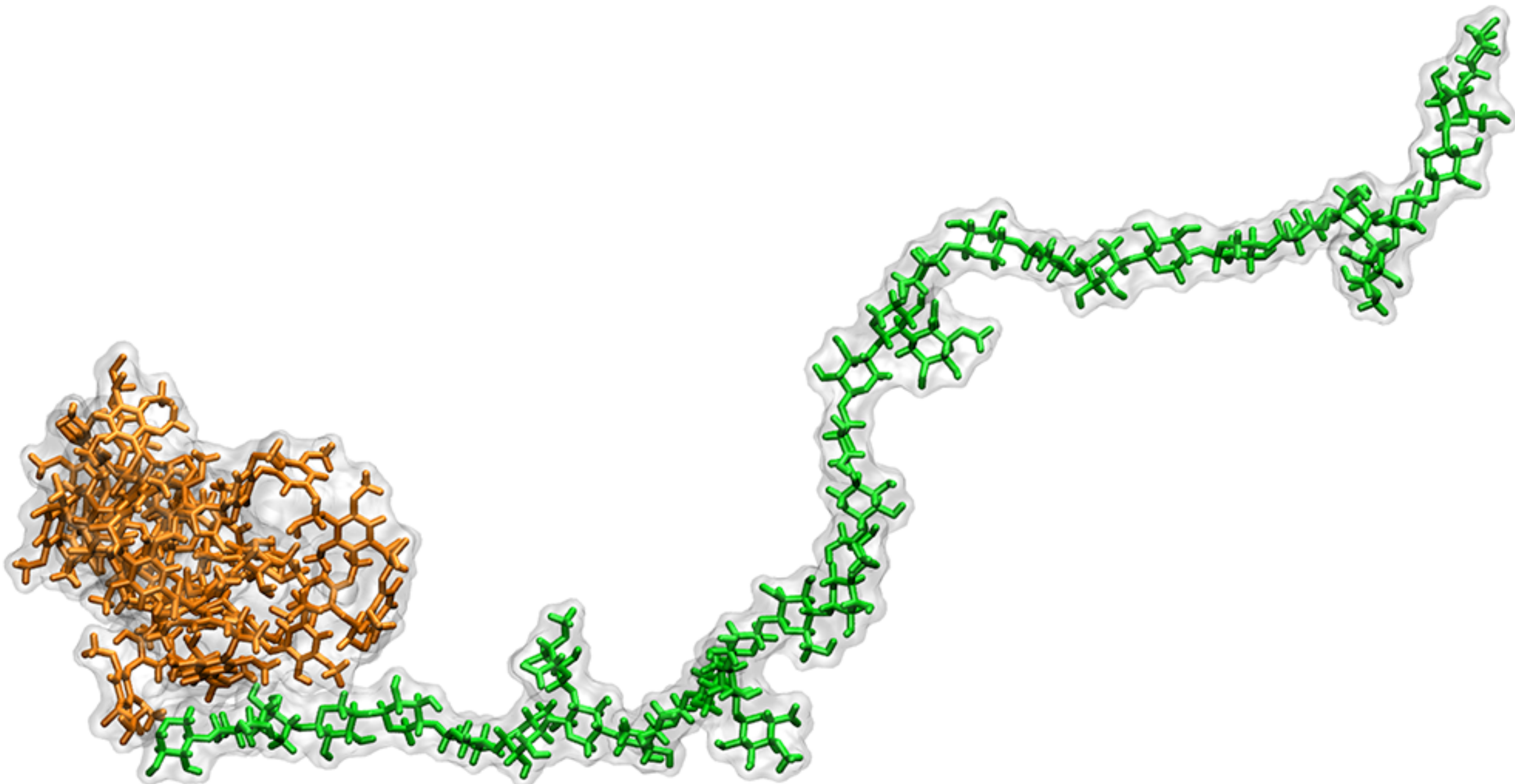
Stellar Explosions and Galaxy Formation: Dark Matter



Find New Medicine: Drug Candidates and their Receptors



Discover New Fuel: Biofuel from Plants



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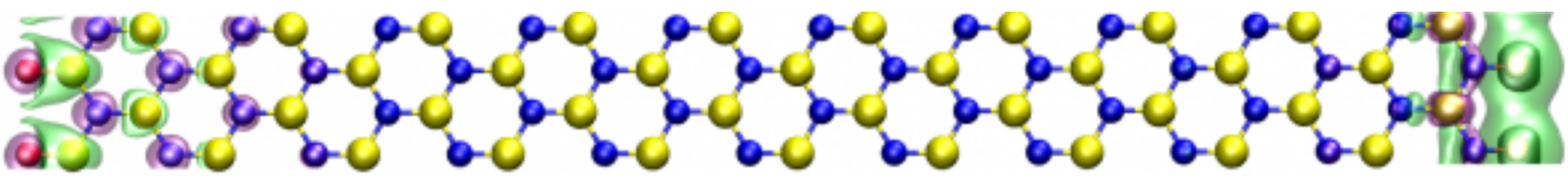
Design New Materials Starting with Atoms

Computer Chips, Communications Equipment, Solar Devices



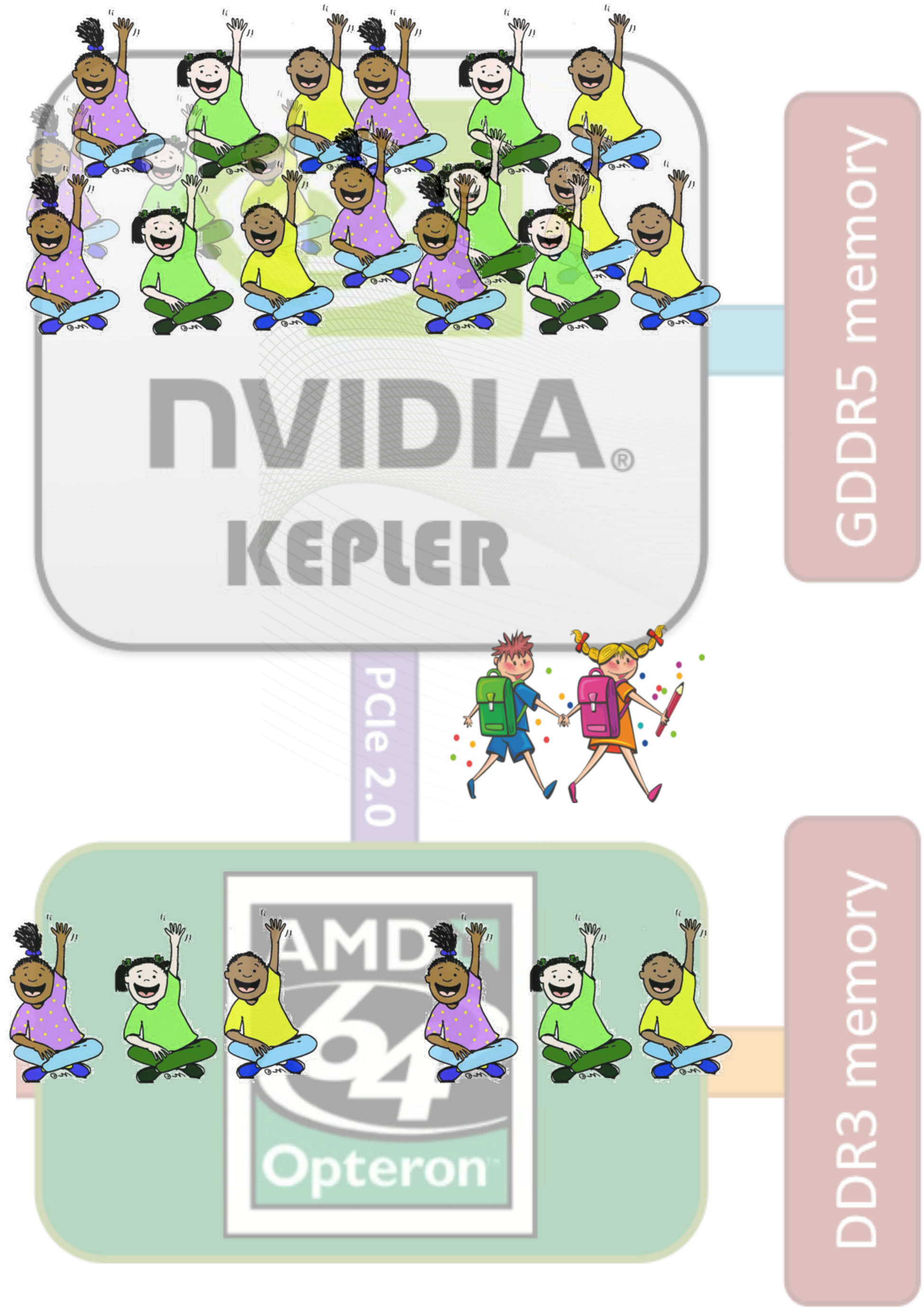
Human Supercomputer

You will be divided into the teams (nodes).

Each person will be a processor.

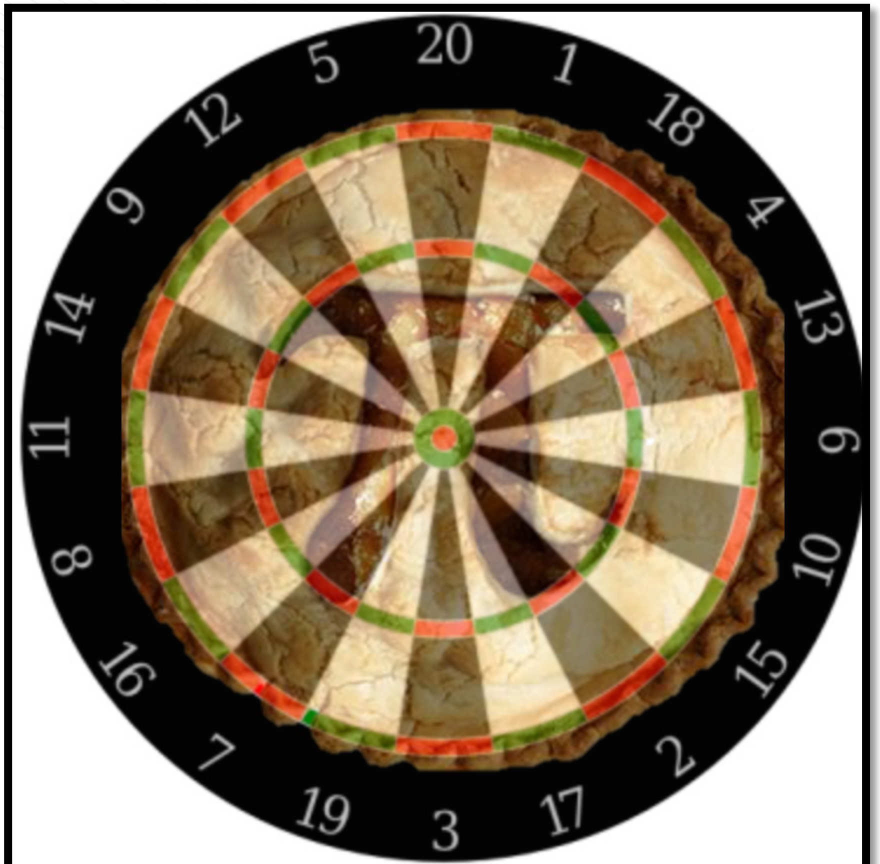
One or two will be messengers that communicate information between processors.

Each node will race to solve a problem.



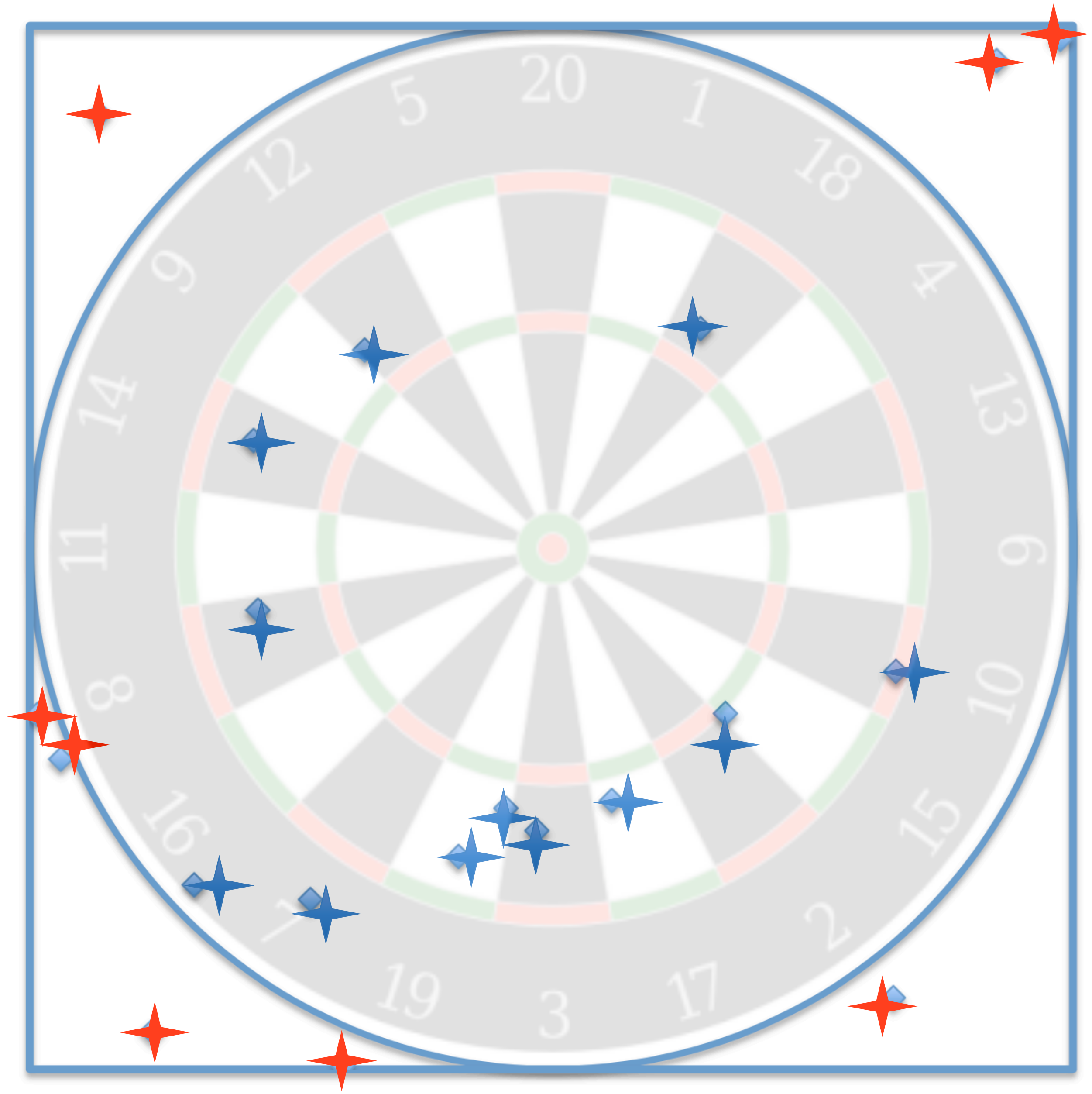
What Will We Solve?

- We are going to estimate the value of π by playing darts: Monte Carlo Method.

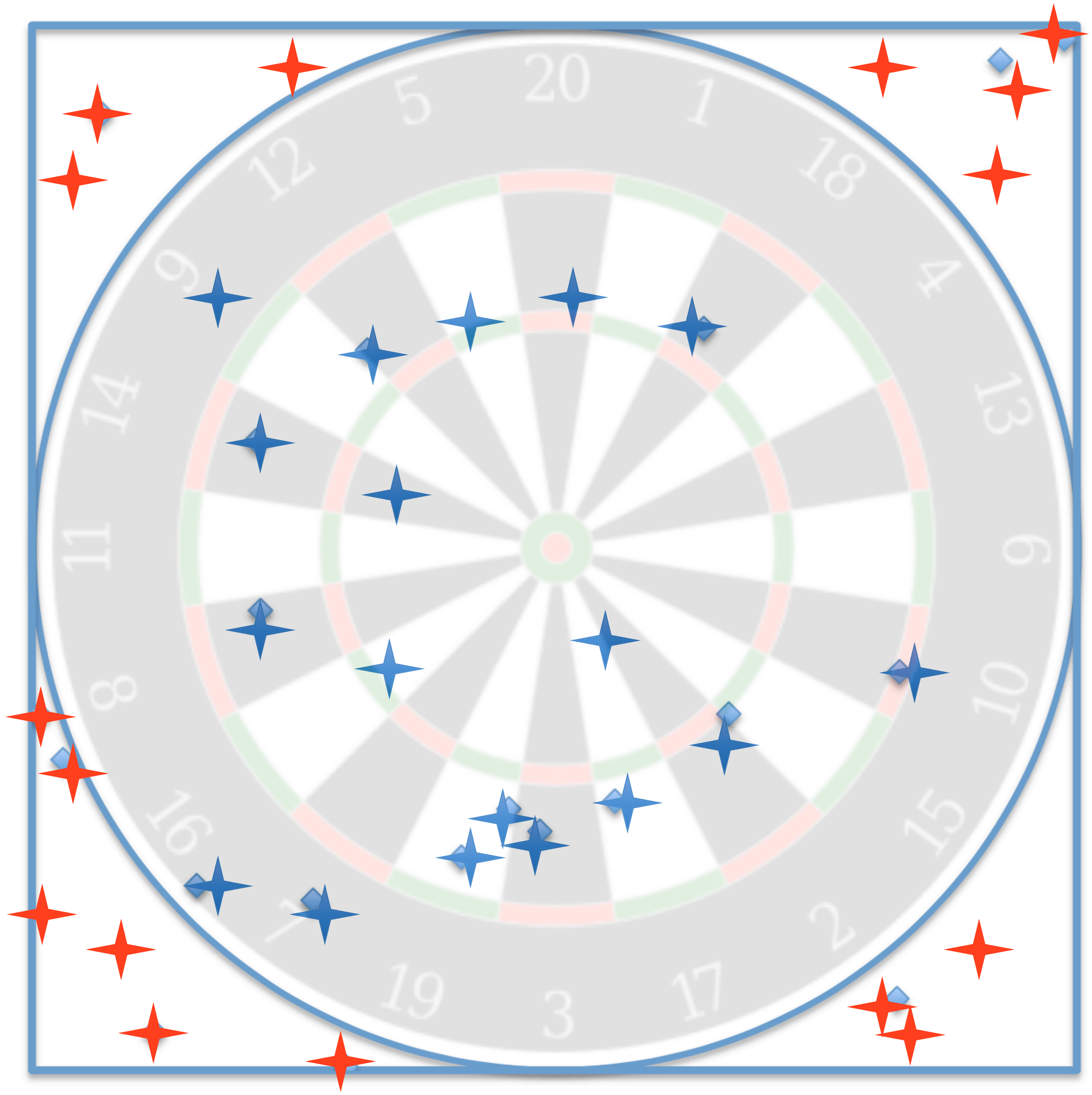


- For this exercise, forget that we now know its value is 3.14159 . . . .
- Often in science we use two or three known things to find something we don't know
- Area of the board $(2r)^2$
- Area of the target: πr^2
- How could we "measure the areas without knowing π?

Assume your aim is only good enough to hit randomly somewhere on the board.

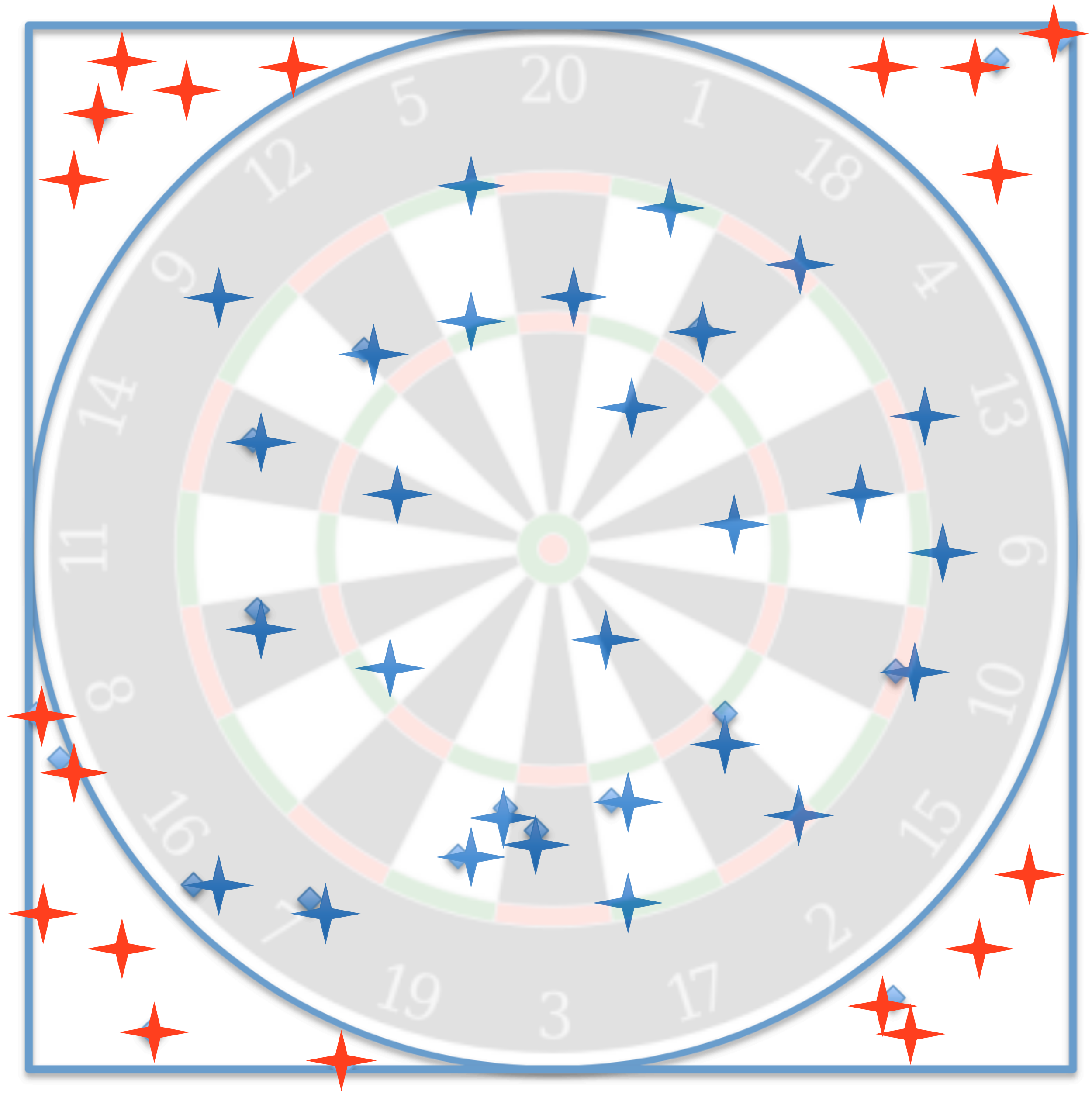


Assume your aim is only good enough to hit randomly somewhere on the board. Throw enough darts and you will



Assume your aim is only good enough to hit randomly somewhere on the board. Throw enough darts and you will

Eventually



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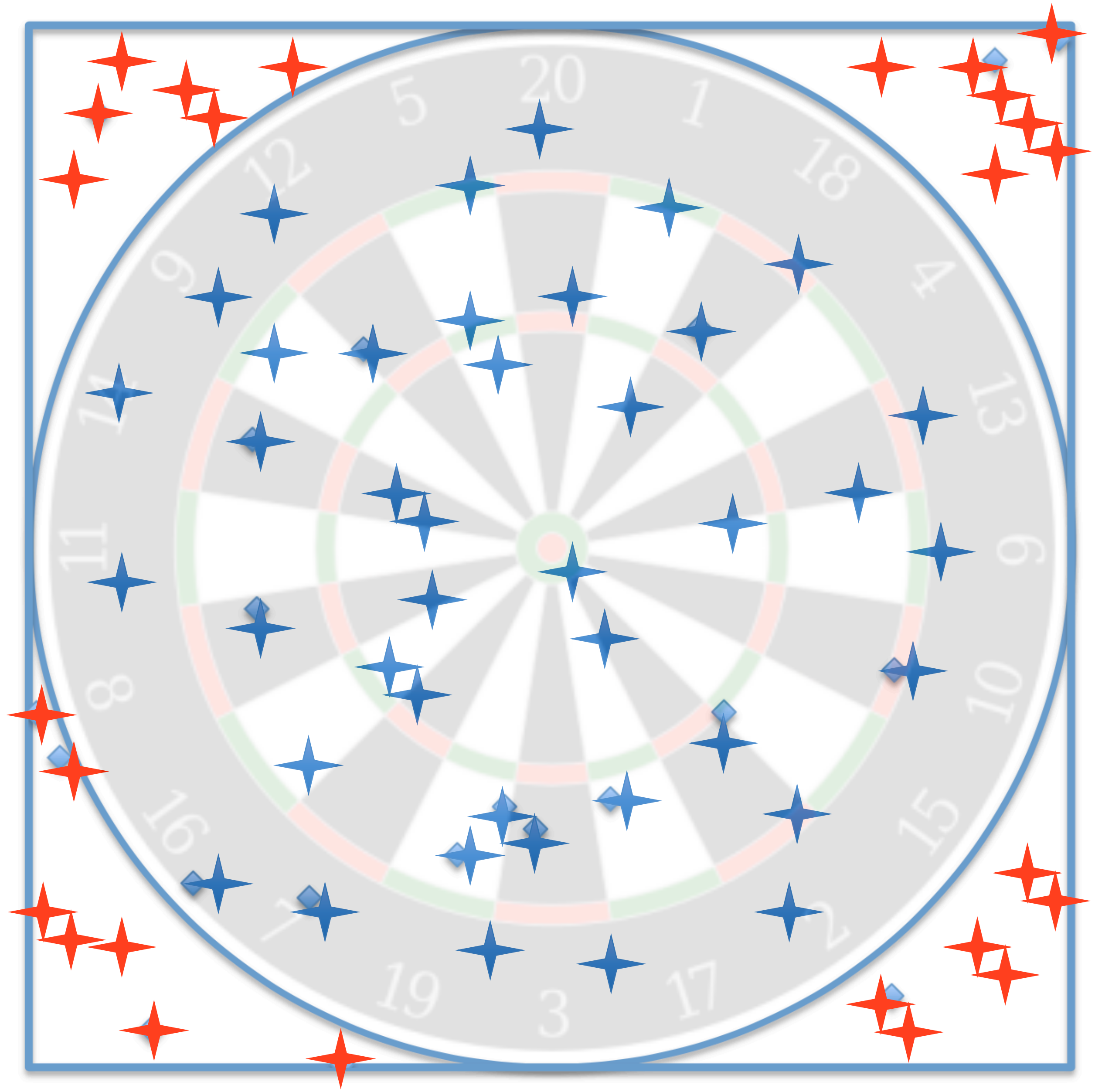
Assume your aim is only good enough to hit randomly somewhere on the board. Throw enough darts and you will

Eventually

cover



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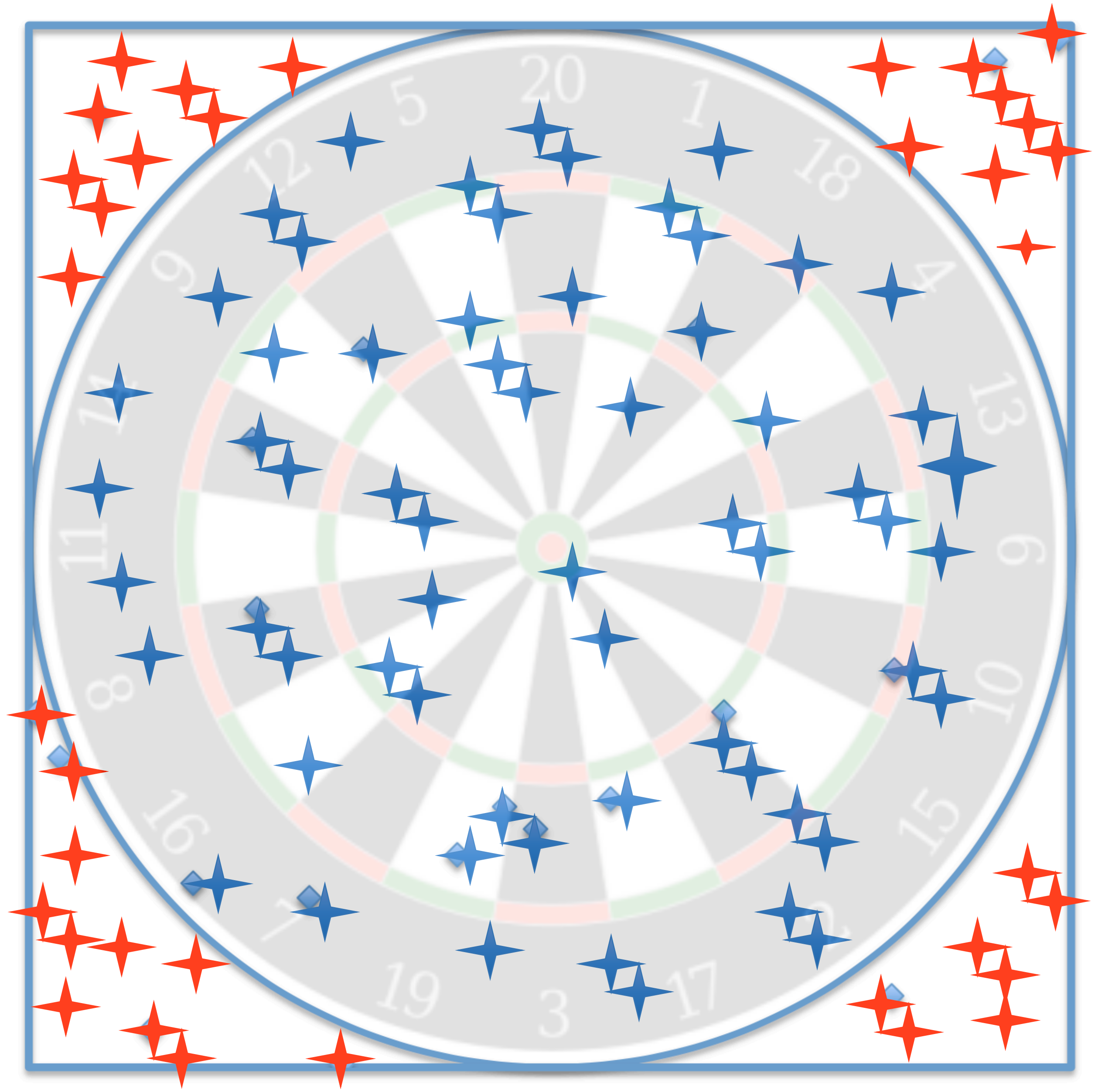
Assume your aim is only good enough to hit randomly somewhere on the board. Throw enough darts and you will

Eventually

cover

The whole



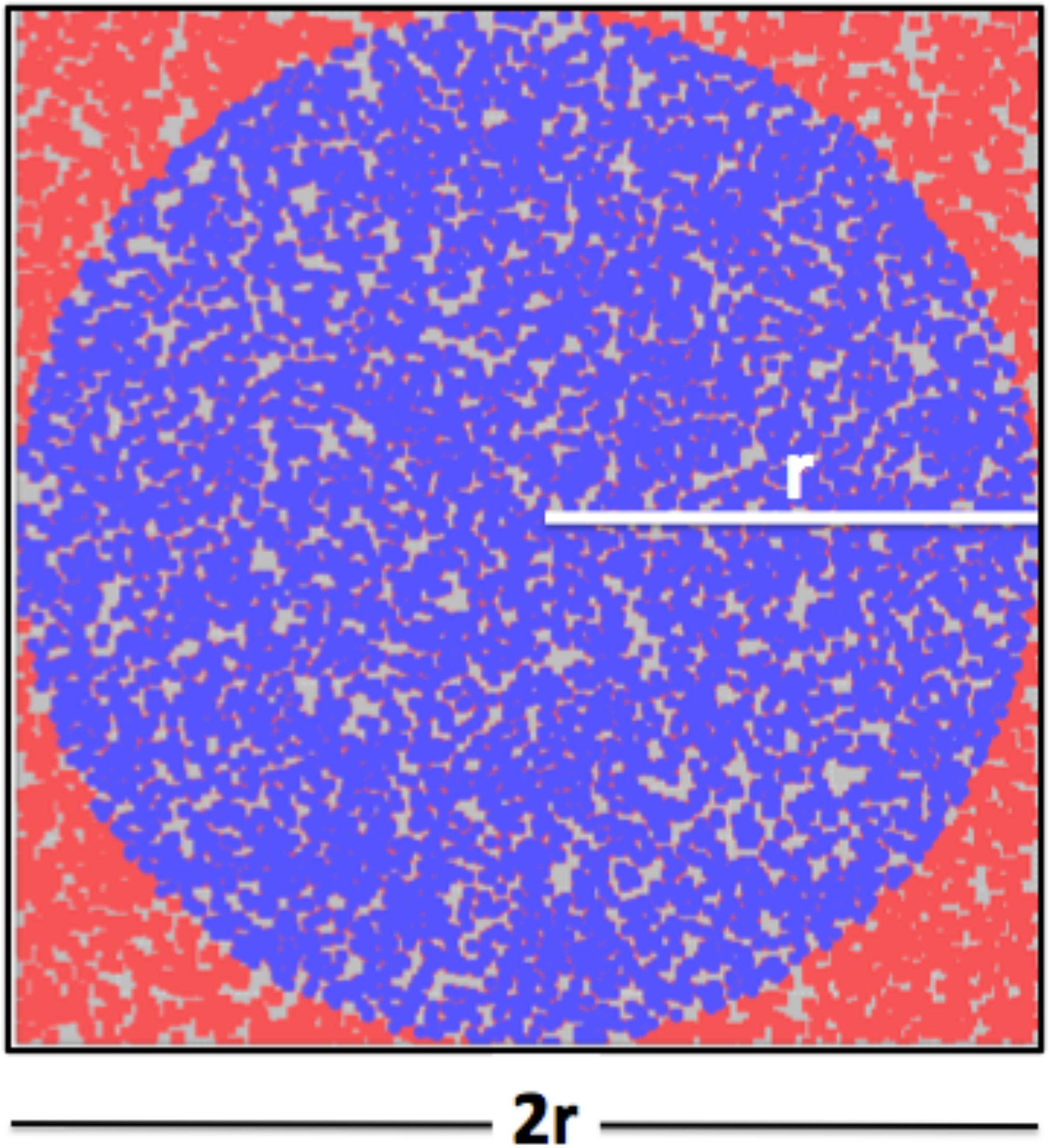
Assume your aim is only good enough to hit randomly somewhere on the board. Throw enough darts and you will

Eventually

cover

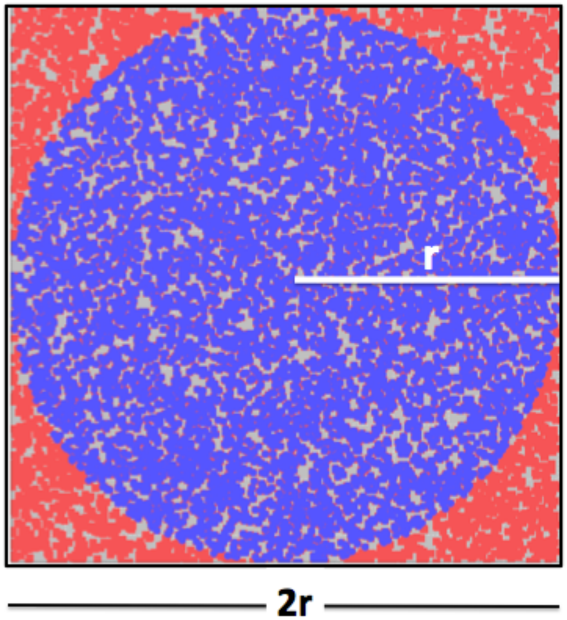
The whole

board!



Playing Darts to Find π

If we have thrown enough darts to cover the board,

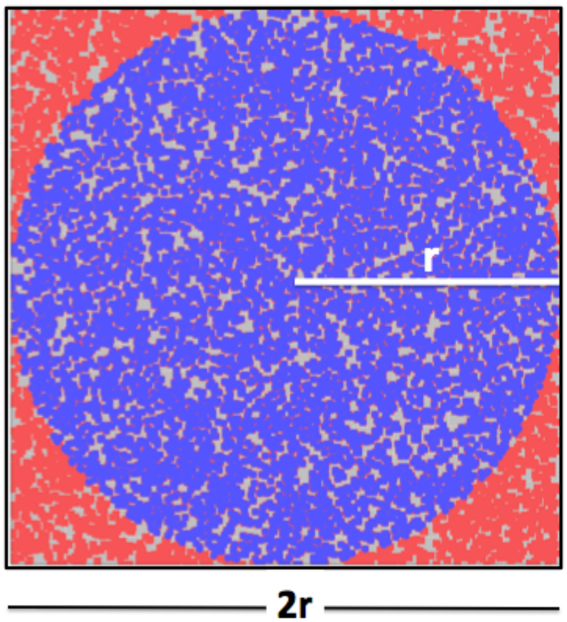


$$\#darts\ circle \cong \text{Area Target circle}$$

$$\#darts\ total \cong \text{Area Board square}$$

$$\frac{\#darts\ circle}{\#darts\ total} \cong \frac{\text{Area Circle}}{\text{Area Board}}$$

Playing Darts to Find π



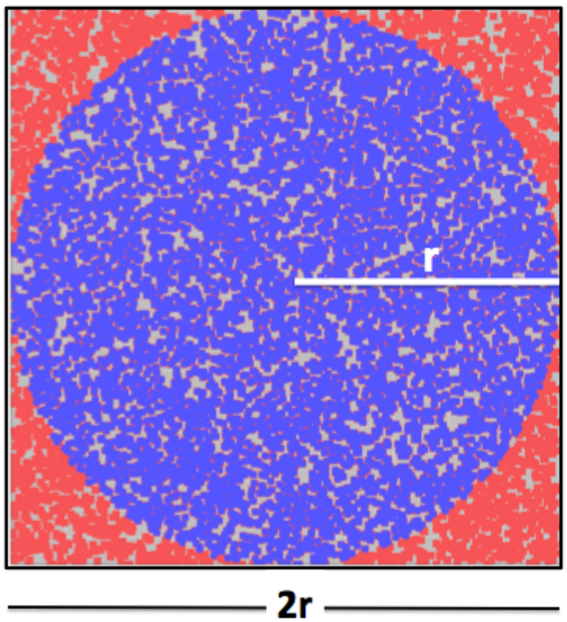
Area of whole board = $2r \times 2r = 4r^2$

Area of target ciricle = πr^2

$$\frac{\#darts\ circle}{\#darts\ total} \cong \frac{\pi r^2}{4r^2} \cong \frac{\pi}{4}$$

$$\pi \cong 4\ \frac{\#darts\ circle}{\#darts\ total}$$

Playing Darts to Find π



If I know that I have 400 total darts,

What can I fill in, in this equation?

$$\pi = 4 \frac{\#darts\ circle}{\#darts\ total}$$

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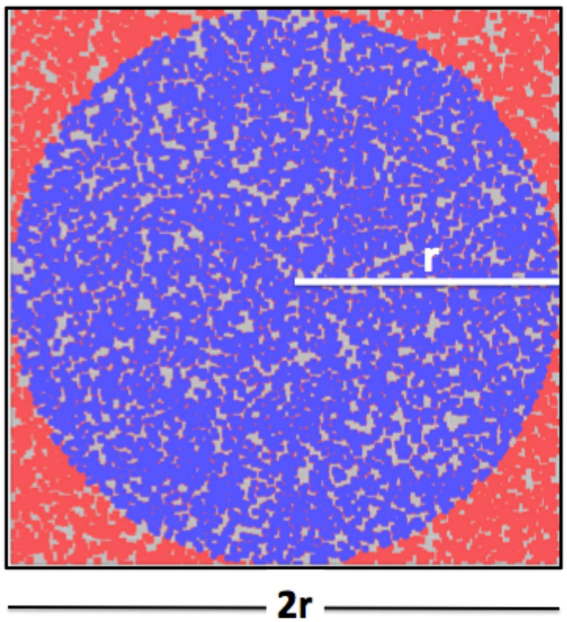
Playing Darts to Find π



If I know that I have 400 total darts,

What can I fill in, in this equation?

$$\pi = 4 \frac{\#darts\ circle}{\#darts\ total}$$

$$\pi = 4 \frac{\#darts\ circle}{400} = \frac{\#darts\ circle}{100}$$

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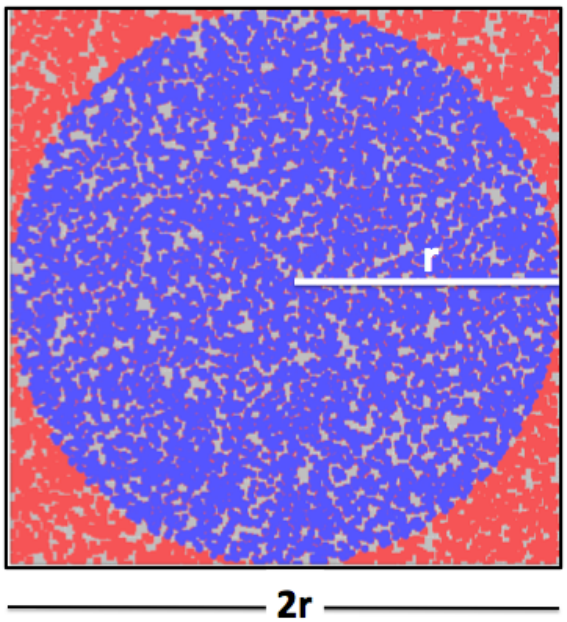
Playing Darts to Find π



It will take all afternoon to play enough games to cover the board. . .

unless we play them all at once.

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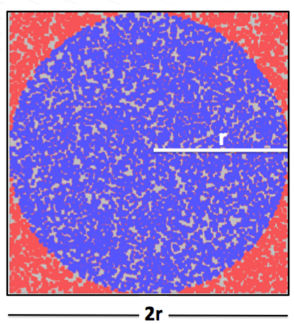
Playing Darts to Find π

Aim within the board is random so 400 darts on one board is the same as 20 games of 20 darts on 20 identical dartboards.



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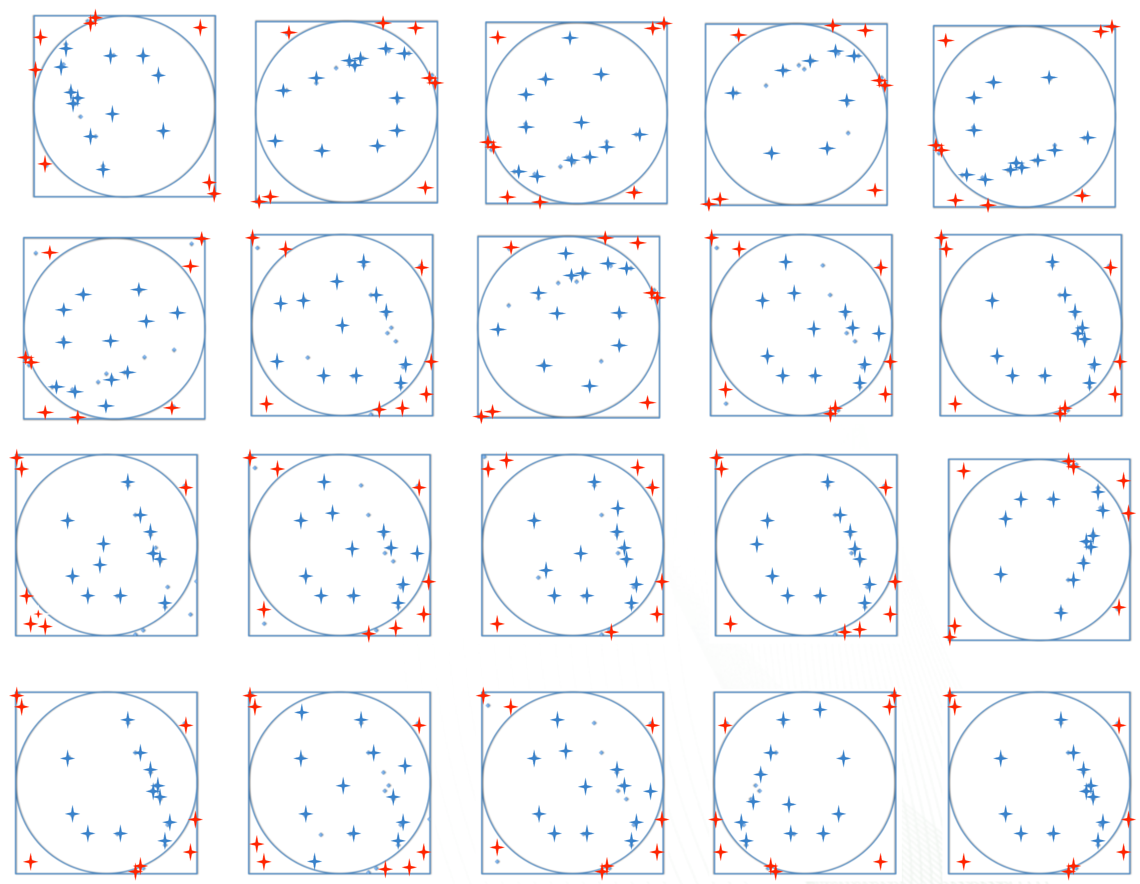
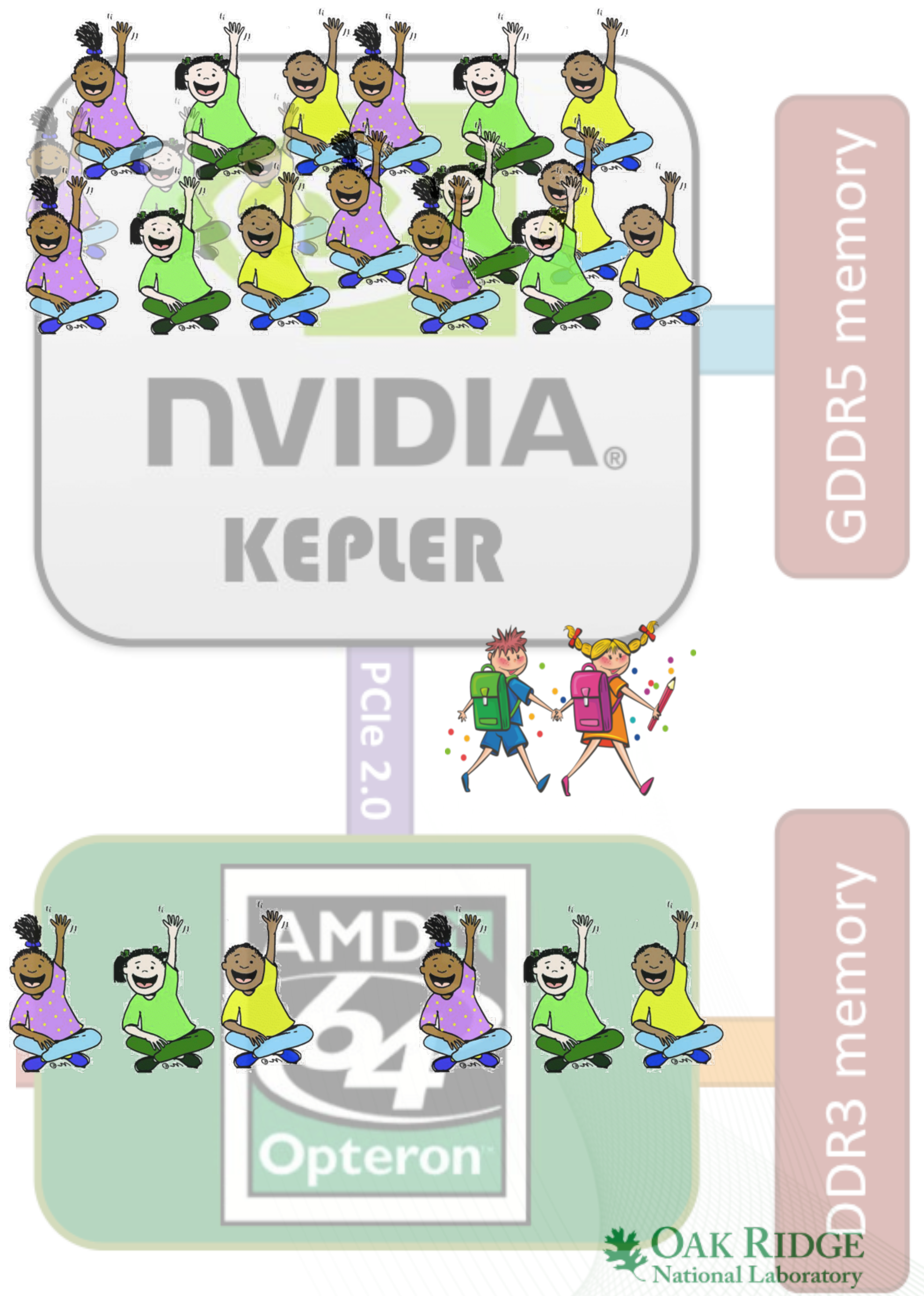


Things to Consider

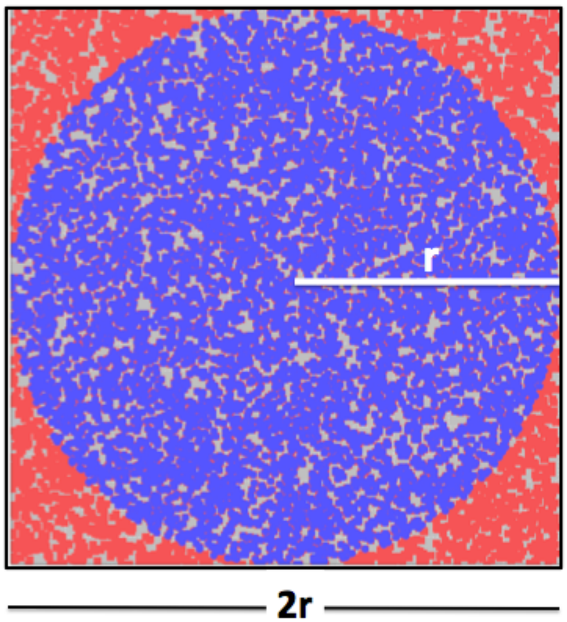
A large team has the advantage for counting. A small team has the advantage for organizing the reduction.

Think about how you will sum the 20 different counts. Will you have one processor add them all up? Will you have two people added 10 each and then add the two counts? Will you find a better way?

How will you error check?



Summary

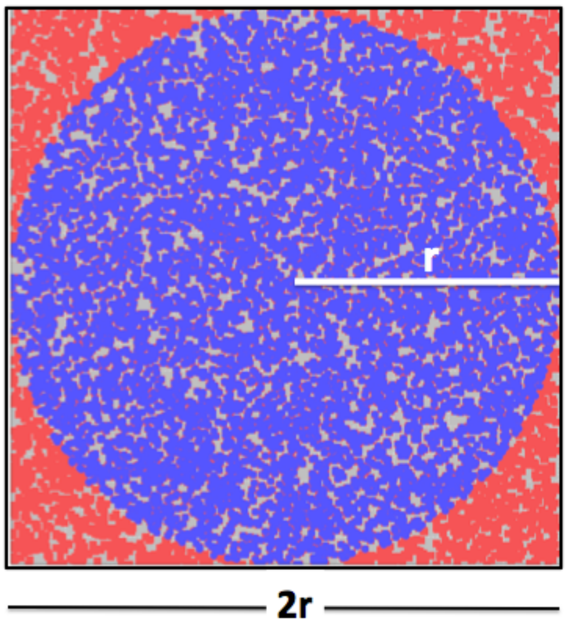


1. Pass out the dartboards.
2. Each person count the number of darts **in the circle.**
3. Enter the number in the array.
4. Sum all the values in the array.
5. Estimate Pi with:

$$\pi \cong \frac{\#darts\ circle}{100}$$

6. Record your team's time
7. Bonus: How could we get a better estimate for π?

Thank You!



This work used resources of the Oak Ridge Leadership Computing Facility, which is a DOE Office of Science User Facility supported under Contract DE-AC05-00OR22725.

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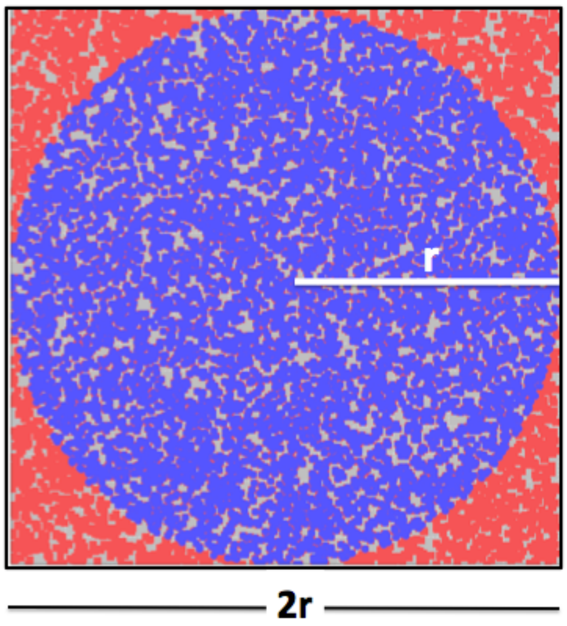
Monte Carlo Pi. C

```c
#include <stdio.h>
#include <stdlib.h>
#include <math.h>

void main(int argc, char* argv[])
{
    double niter = 10000000;
    double x,y;
    int i;
    int count=0;
    double z;
    double pi;
    srand(time(NULL));
    //main loop
    for (i=0; i<niter; ++i)
    {
        //get random points
        x = (double)random()/RAND_MAX;
        y = (double)random()/RAND_MAX;
        z = sqrt((x*x)+(y*y));
        //check to see if point is in unit circle
        if (z<=1)
        {
            ++count;
        }
    }
    pi = ((double)count/(double)niter)*4.0;          //p = 4(m/n)
    printf("Pi: %f\n", pi);
```

Playing Darts to Find π



Kernel: Human supercomputer, count the darts in the circle on the 20 dartboards and enter them in the "array."
Reduction: Sum the 20 counts! To get *# darts circle.*
Result: Put *# darts* circle in the equation below to get your estimate for Pi, then report your result to us. You will be timed. The fastest team wins.

$$\pi = 4\ \frac{\#darts\ circle}{400} = \frac{\#darts\ circle}{100}$$