How 6 River Systems Leveraged the Use of ROS and the NVIDIA Jetson Platform to Build a Fleet of Autonomous Collaborative Robots

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FOLLOW THE LEADER

Introducing Chuck!

Compliant to *ANSI b56.5* safety standard. *Experienced* team has designed, sold, built, and deployed systems with *+10,000* robots in use

1. **Eliminates long walks**
   Brings work to the associate
2. **Reduces in aisle walking**
   Intelligent order allocation
3. **Speeds up the task**
   Directed workflow, 3x rates, 15 minute training

Changing Operations

10 years

Fast growing business?
You've 3 options

Do it yourself

But traditional automation and software is inflexible, complex and expensive

Outsource to 3PL

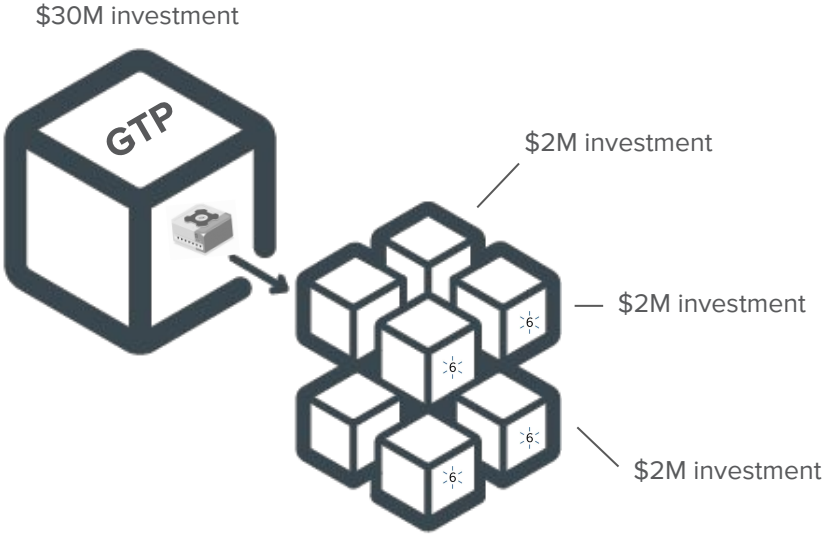
But you are locked into a multi-year contract and you lose control

Give it to Amazon

But you lose the relationship with your customer, live and die by their rules and pay high fees

What if you could get 80% of the value at 20% of the cost?

We realized you can achieve comparable value to traditional automation by shrinking it down into on-demand services



Rapid Go-live

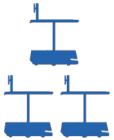
Accelerate time to value, increasing benefit

4 weeks

SOLUTION DESIGN

Our solutions team will create a concept and work with you to finalize a design and proposal based on your objectives.

2 weeks



DEPLOYMENT

Your program manager will get robots on the ground, map your warehouse and lead integration with your existing systems.

LAUNCH

We'll make sure you have a solid launch and project plan in place. Your associates will be out in the aisles with Chuck right away.

1 INDUCT

Cloud-based intelligent work allocation groups similar work to reduce associate walking between tasks.

2 MEET

Chuck eliminates the long walk by bringing the work directly to the associates in the active area.

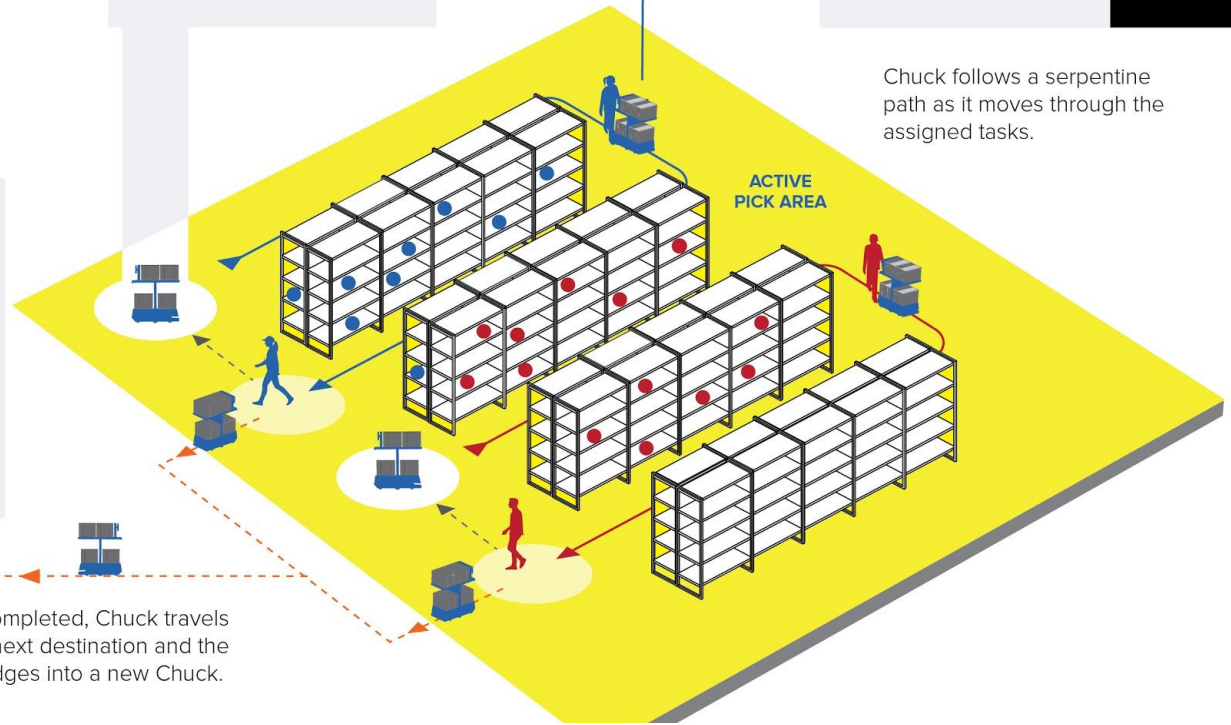
3 PICK

Chuck leads the associate through their assigned tasks.

How Chuck makes the task faster

- Directed
- Lights
- Images
- Scanner
- Hands-free

Chuck follows a serpentine path as it moves through the assigned tasks.



4 TAKEOFF

Chuck can sort exceptions from completed orders and deliver orders to different points across the warehouse.

After job is completed, Chuck travels alone to the next destination and the associate badges into a new Chuck.

Summary

6 River Systems is the new way companies fulfill

We deliver collaborative, insightful and adaptive automation and fulfillment systems.

2015
founded by ex-Kiva executives

25+
sites deployed in US, Canada & Europe

$46M
raised investors

100+
employees

1M
units fulfilled per week

$5B
total market

We make educated bets

We do our homework, present it in simple ways and aren't afraid to make calculated and bold decisions.

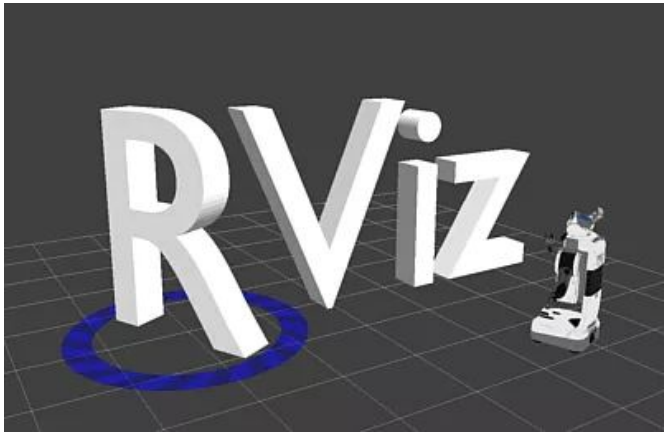
Our first big decision

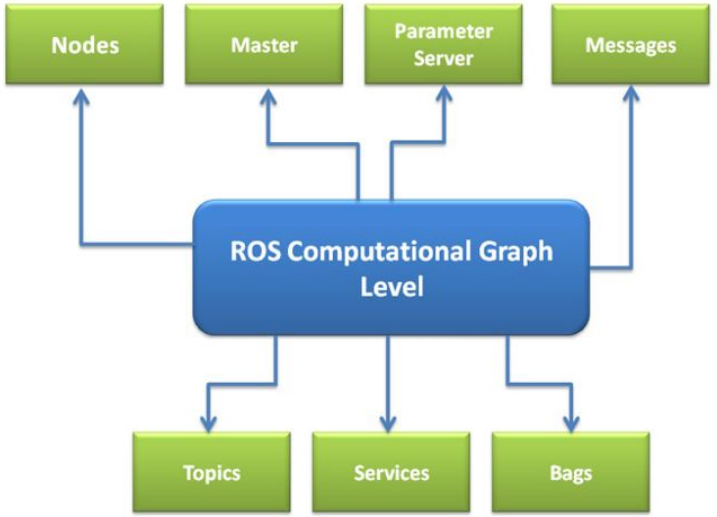
ROS

Homegrown Framework

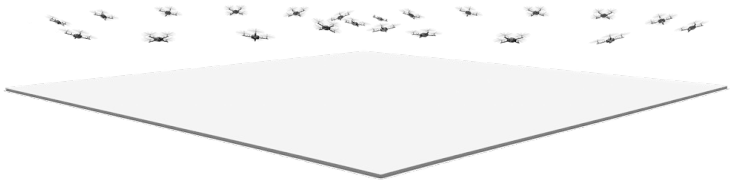
ROS was an easy choice

Infrastructure and Tools





Large Active Community



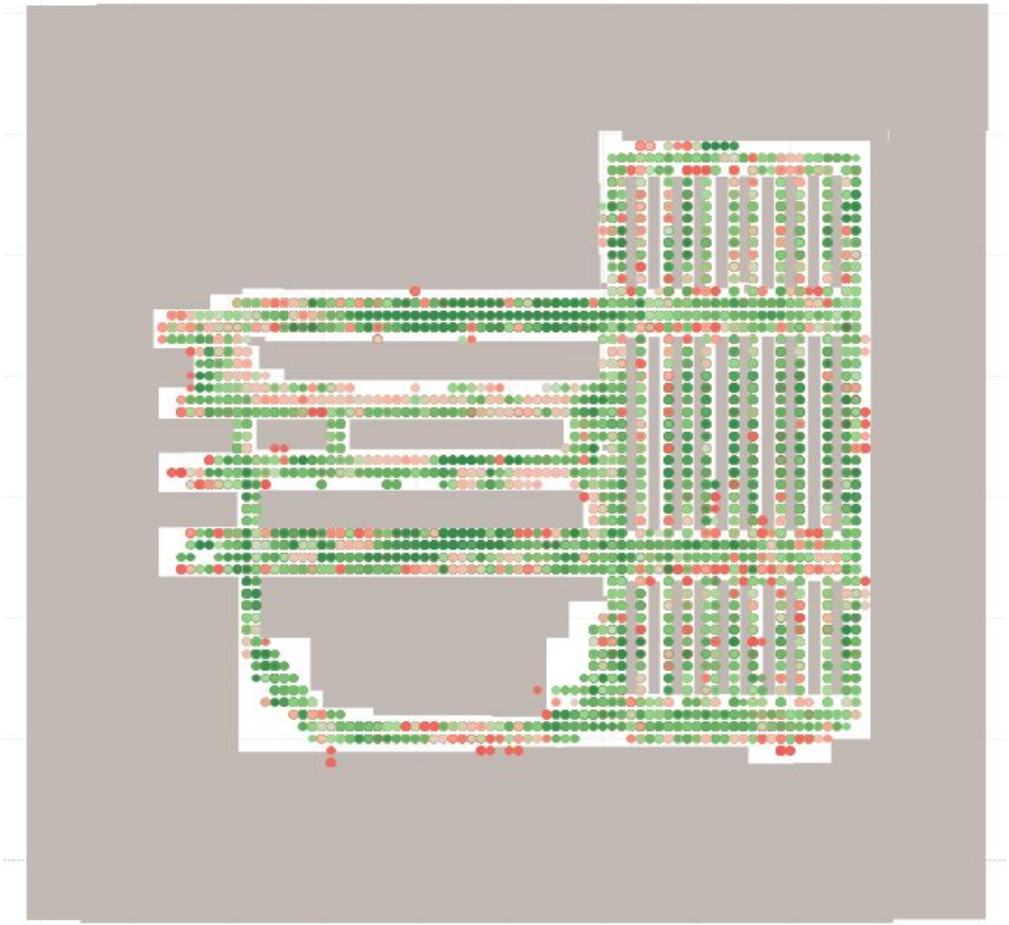
1. Over 2,400 packages and many more added every week
2. Built in support for most sensors
3. Community

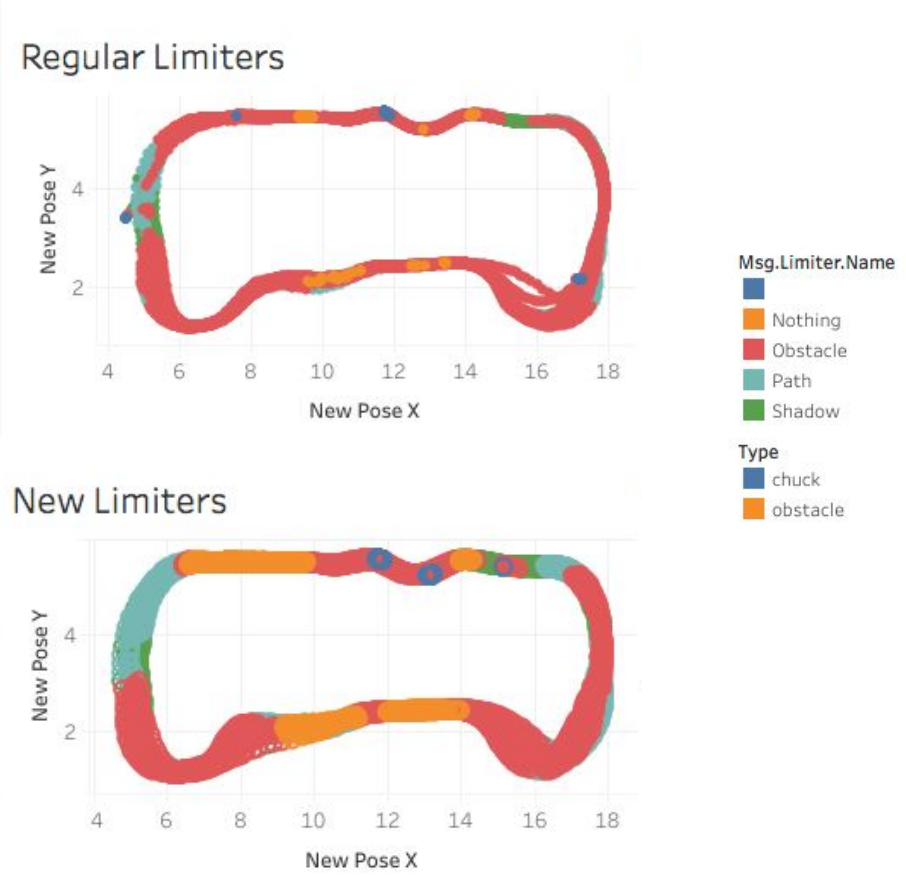
ROS BAG

- An airplane “blackbox”
- Only way to debug complicated scenarios
- Able to leverage architecture to record complex analytics

Data Driven Analytics

We capture data from robots in real time to help understand and optimize performance and identify efficiency improvements in the warehouse.



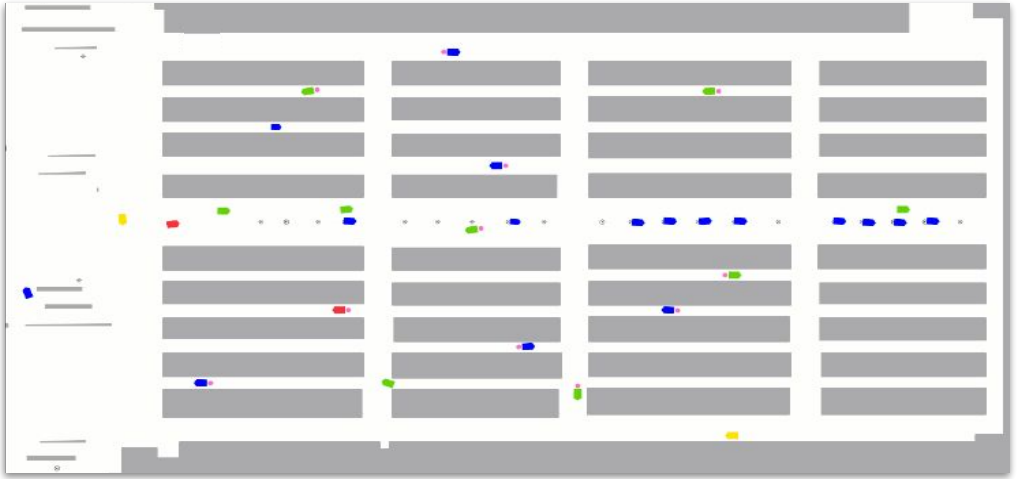


Speed Analysis

Using data collected, 6 River Systems can enhance AI Algorithms that allow chuck to move more intelligently in the real physical world.

Real Time Data

We are able to predict and warn customers of problems by analyzing data streamed in real time from robots.

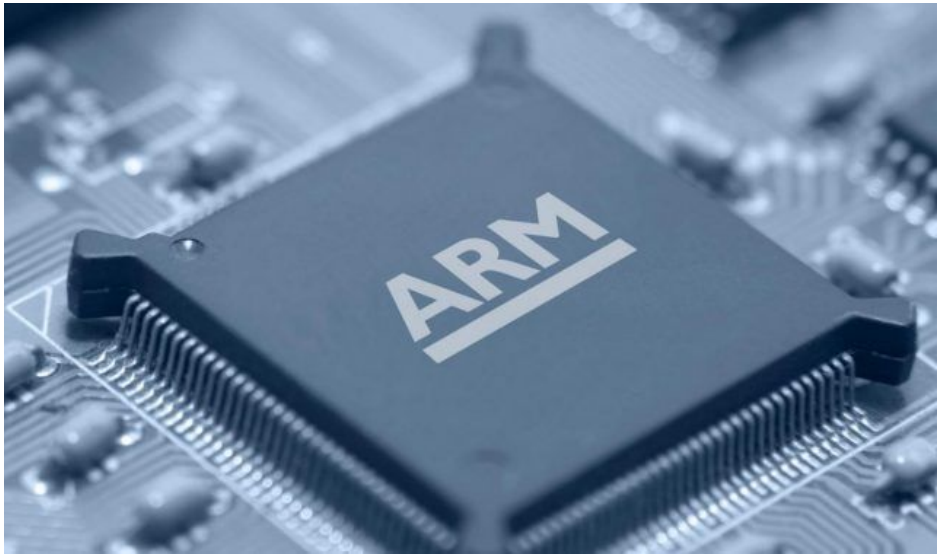


We had our second big choice to make

Made a bet on the TX1

GPU: 1 teraflops, 256-core GPU
CPU: 64-bit ARM A57 CPUs
Video: 4K video encode and decode
Camera: Support for 1400 megapixels/second
Memory: 4GB LPDDR4; 25.6 gigabytes/second
Storage: 16GB eMMC
Wi-Fi/Bluetooth: 802.11ac 2x2 Bluetooth ready
Networking: 1GB Ethernet

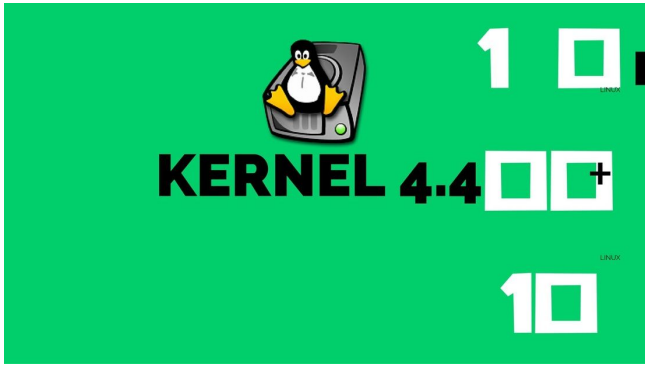
Early Challenges



No support for arm64

Electron
Electron Packager
NoMachine
ZeroTier
…

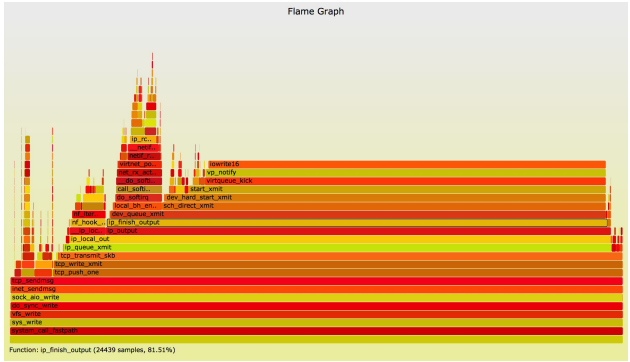
Early Challenges



Safety

- Captured and analyzed metrics from the field
- Latency was inconsistent and larger than expected
- Processing of data was not consistent (spikes and real world data did not match testing environment)

Performance Tuning



CPU 0	
1	6
2	4
3	5

CPU 1	
1	6
2	4
3	5

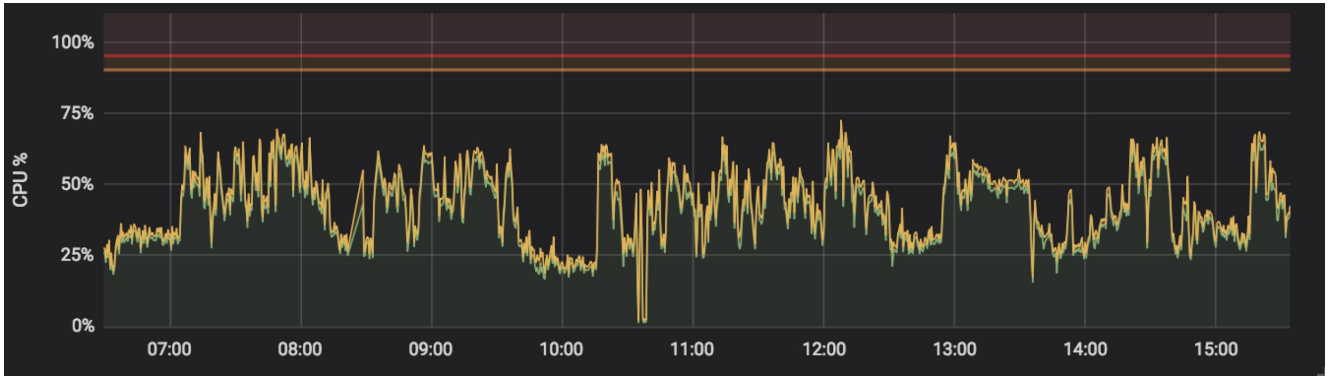
CPU 2	
1	6
2	4
3	5

CPU 3	
1	6
2	4
3	5

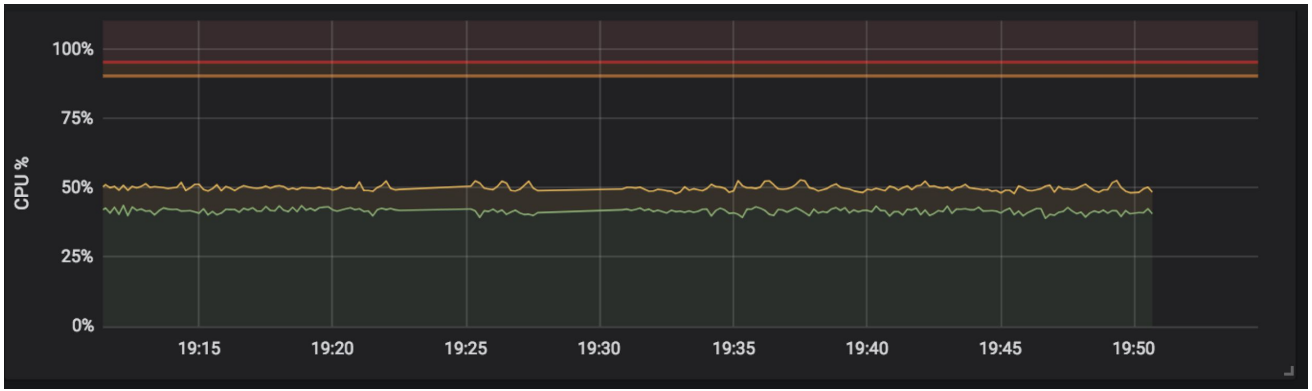
With CPU Affinity Set
Only CPU 0 and 1 are used

- Processor Affinity
- Memory bandwidth
- Compiler optimizations
- Pipeline optimizations
- Code optimizations
- CUDA

Before



After

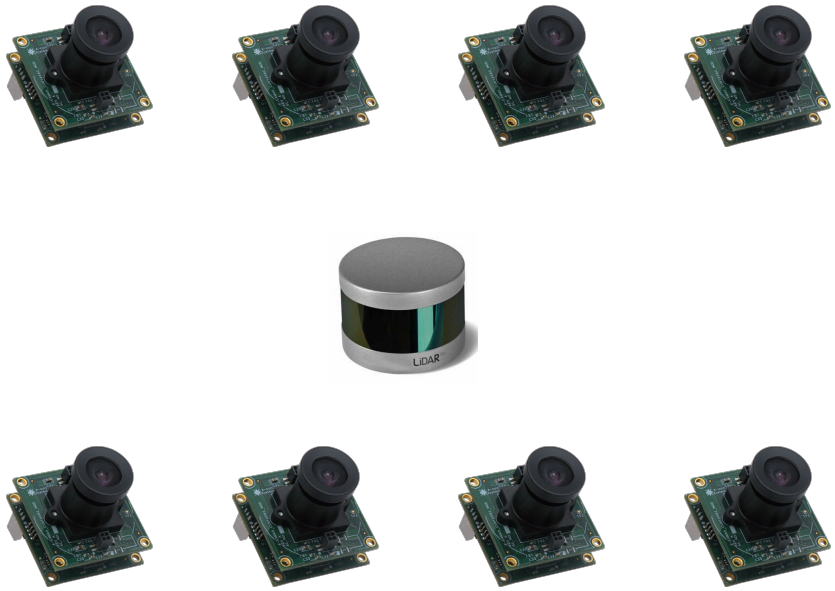


1. 2x the performance (movement, perception and safety) overnight
2. Drop in replacement with no hardware changes
3. Allowed team to focus on other business and customer problems
4. Linux Kernel 4.4 Support!

Move to the TX2

NVIDIA Jetson TX2 Delivers Twice the Intelligence to the Edge

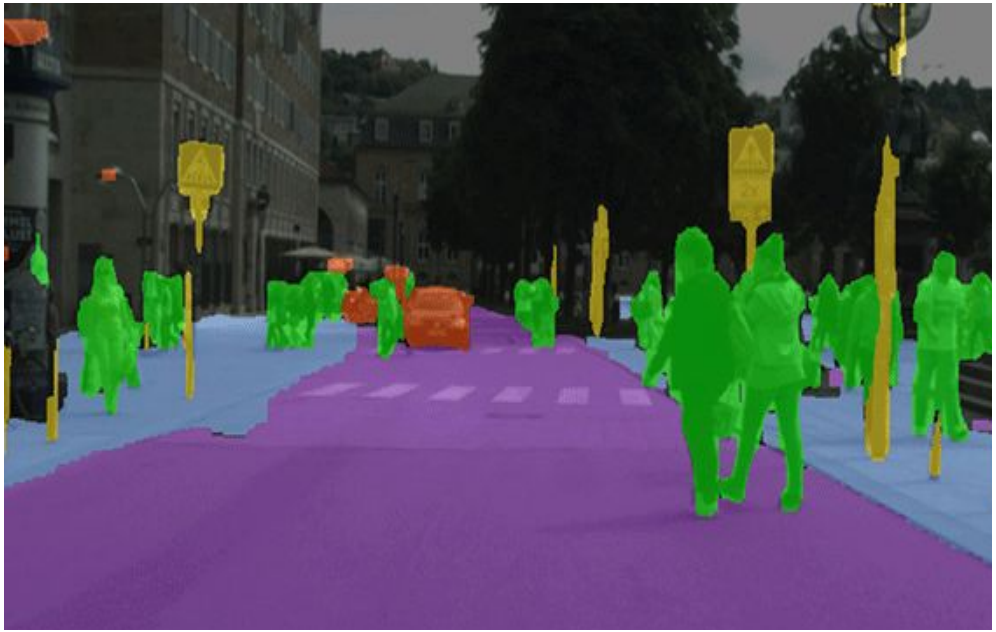
Sensors, we need more sensors!

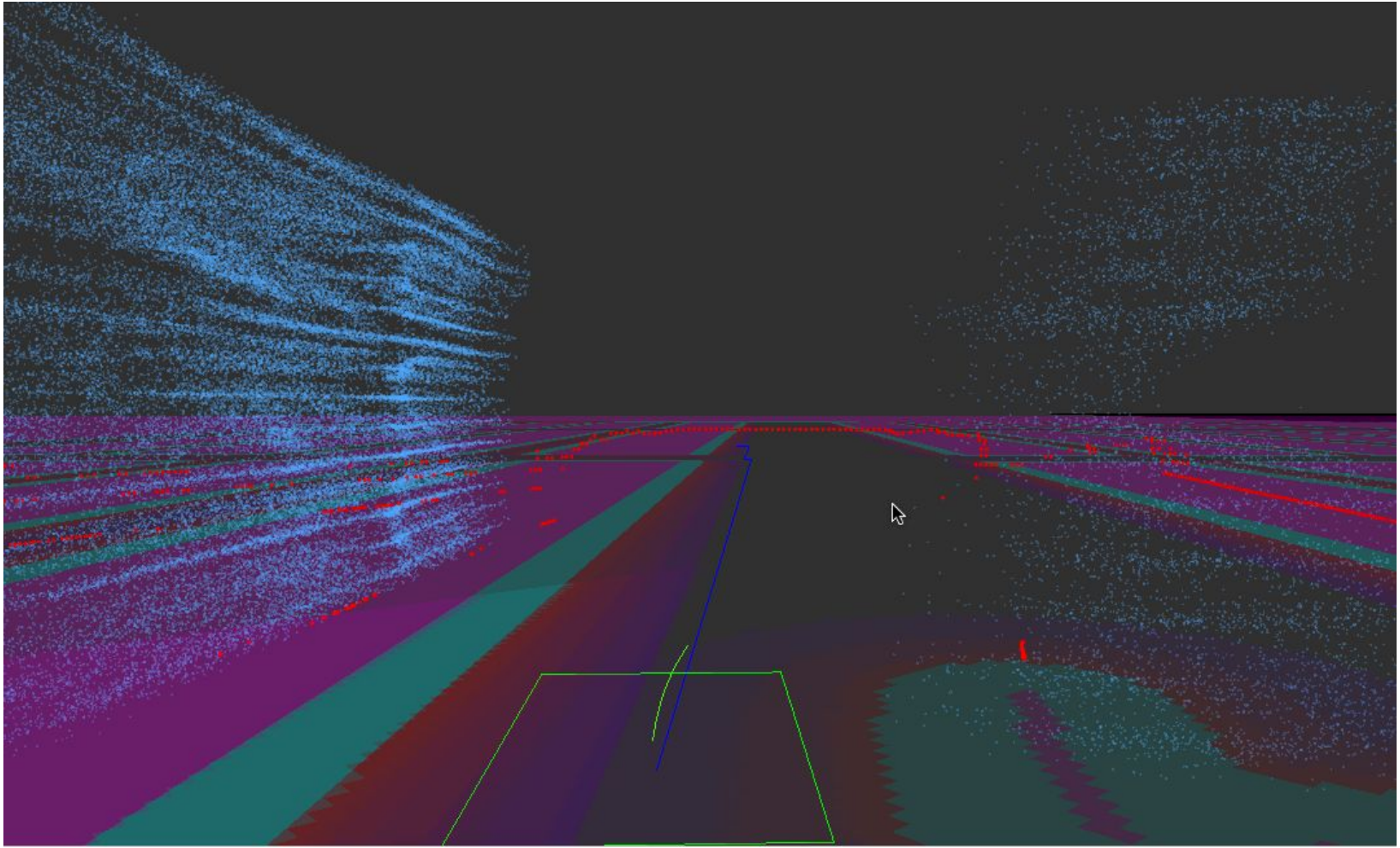


1. Additional sensors and move to processing point clouds instead of laser scans
2. Over 7000x increase in data processed
3. Time to process data on the GPU!

Future Work

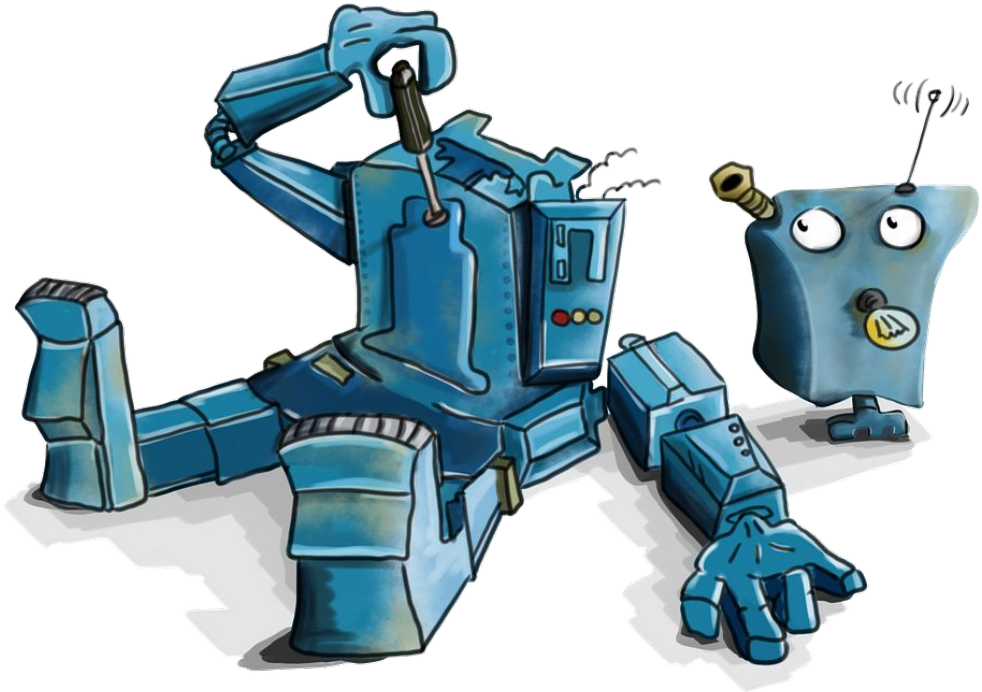
- CUDA Graphs
- CUDA 10 Performance optimizations
- Developer Tools





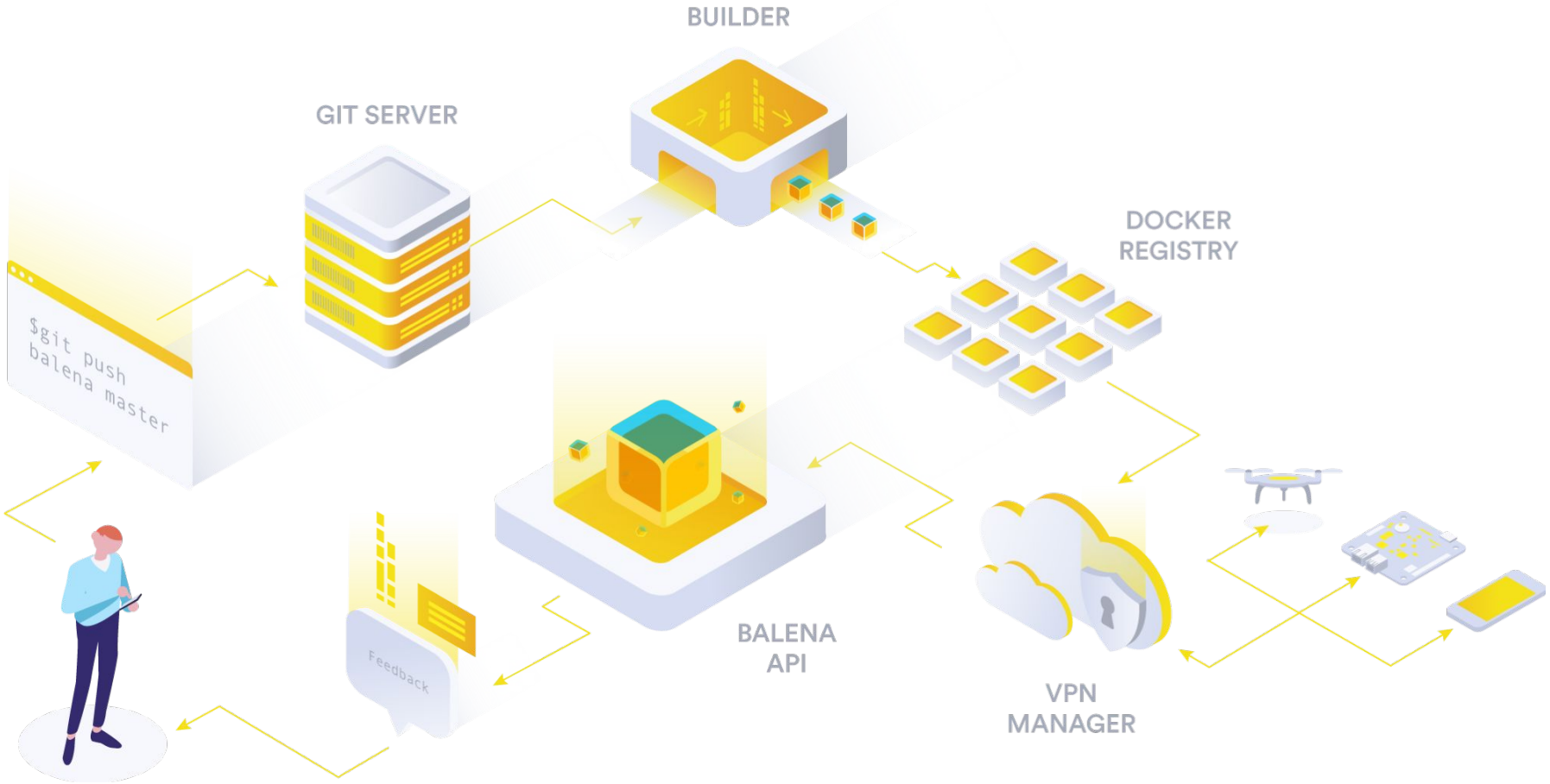
Updating Robots

- Updating robots was a manual process and very time consuming
- Forced to run updates one robot at a time due to unstable networks
- Robots would frequently lose connection and end up in a bad state

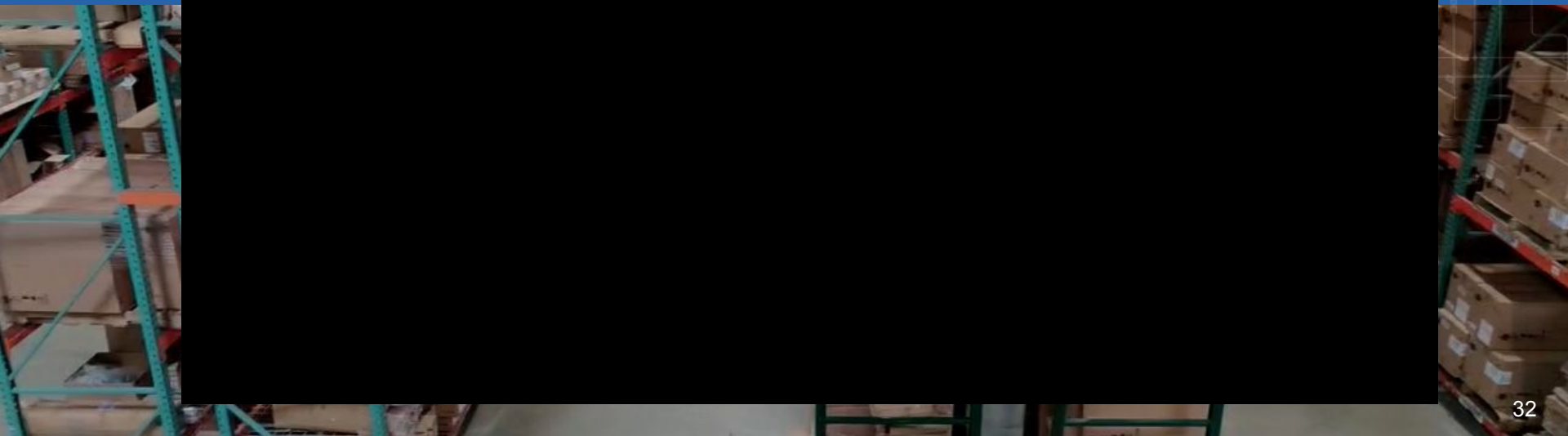


Balena.io to the rescue!

1. Worked with balena team to add support for TX1/TX2
2. Seamless updates running all code in a pre-built docker image
3. Docker diffs allowed quick updates



6 RIVER SYSTEMS



We're Hiring

FOLLOW THE LEADER