BLUE SKY SOLAR RACING

Blue Sky Elec

Towards the Next Generation Vehicle Compute Platform

Contents

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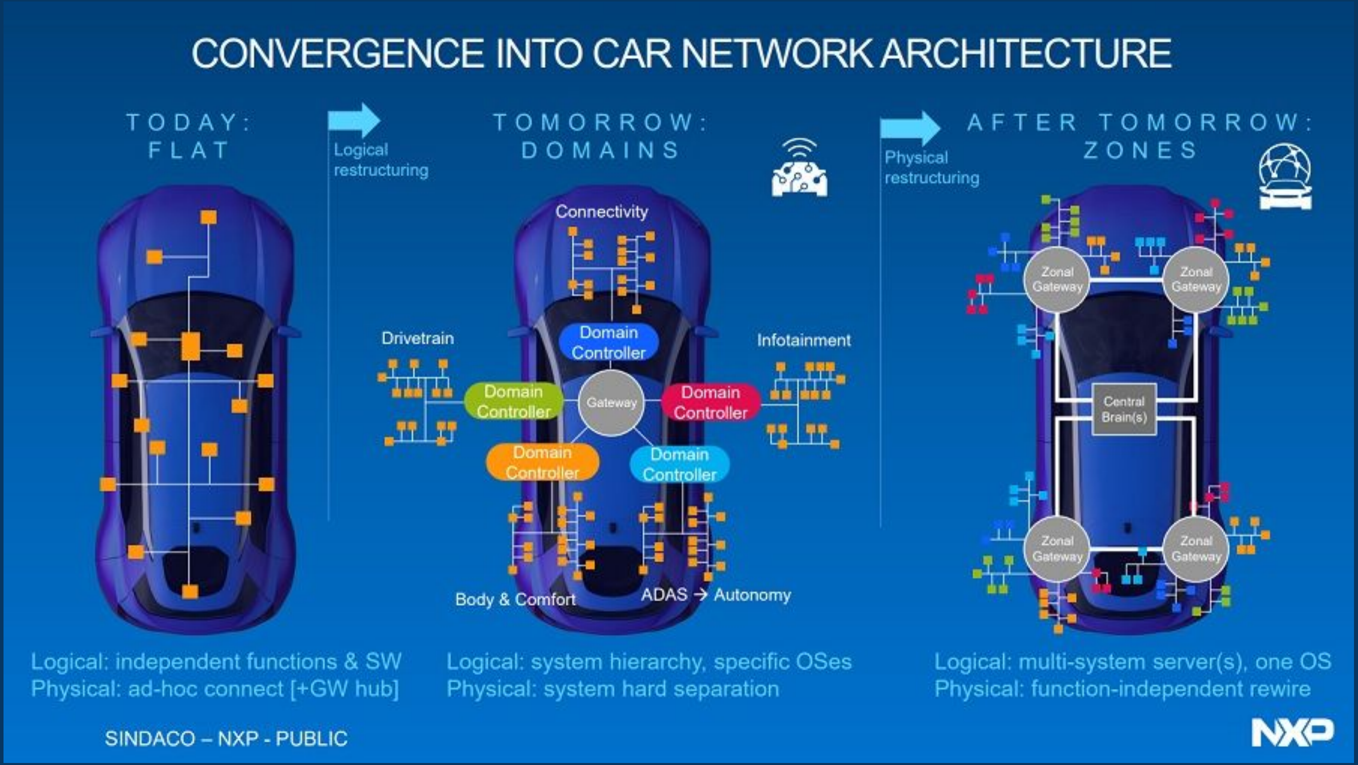
Decentralized vs Centralized Platform


CONVERGENCE INTO CAR NETWORK ARCHITECTURE
TODAY: FLAT
Logical restructuring
TOMORROW: DOMAINS
Physical restructuring
AFTER TOMORROW: ZONES
Connectivity
Drivetrain
Infotainment
Domain Controller
Gateway
Body & Comfort
ADAS → Autonomy
Zonal Gateway
Central Brain(s)
Logical: independent functions & SW
Physical: ad-hoc connect [+GW hub]
Logical: system hierarchy, specific OSes
Physical: system hard separation
Logical: multi-system server(s), one OS
Physical: function-independent rewire
SINDACO – NXP - PUBLIC
NXP

Centralized Platform Examples

ANNOUNCING NVIDIA DRIVE THOR
2000 TFLOPs FP8
77B Transistors
Inference
Transformer Engine
Multi-Domain
Computing Isolation
NVLink-C2C
Scalability

Nvidia: THOR

STELLANTIS
STLA Brain
Powered by
Snapdragon
digital chassis
Snapdragon Digital Chassis is a product of Qualcomm Technologies, Inc. and/or its subsidiaries.

Qualcomm: Digital Chassis

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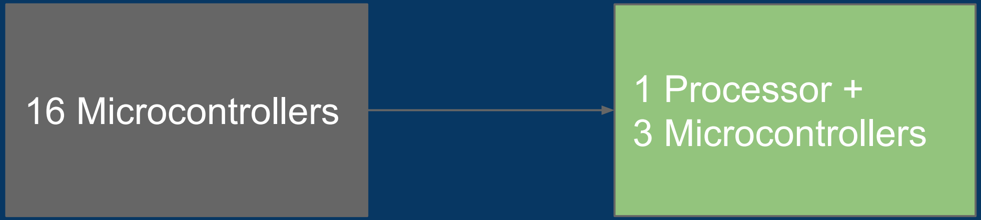
Why Blue Sky needs a Centralized Platform

- 75 percent reduction in programmable chips



- 70 percent reduction in wiring
- 50+ percent reduction in power consumption
- Infinite increase in software flexibility (remote software update, local strategy simulation)
- Remove state inconsistency introduced by a distributed system

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Challenges of a Centralized Platform

Lack of Modularity

Single Point of Failure

Program Complexity

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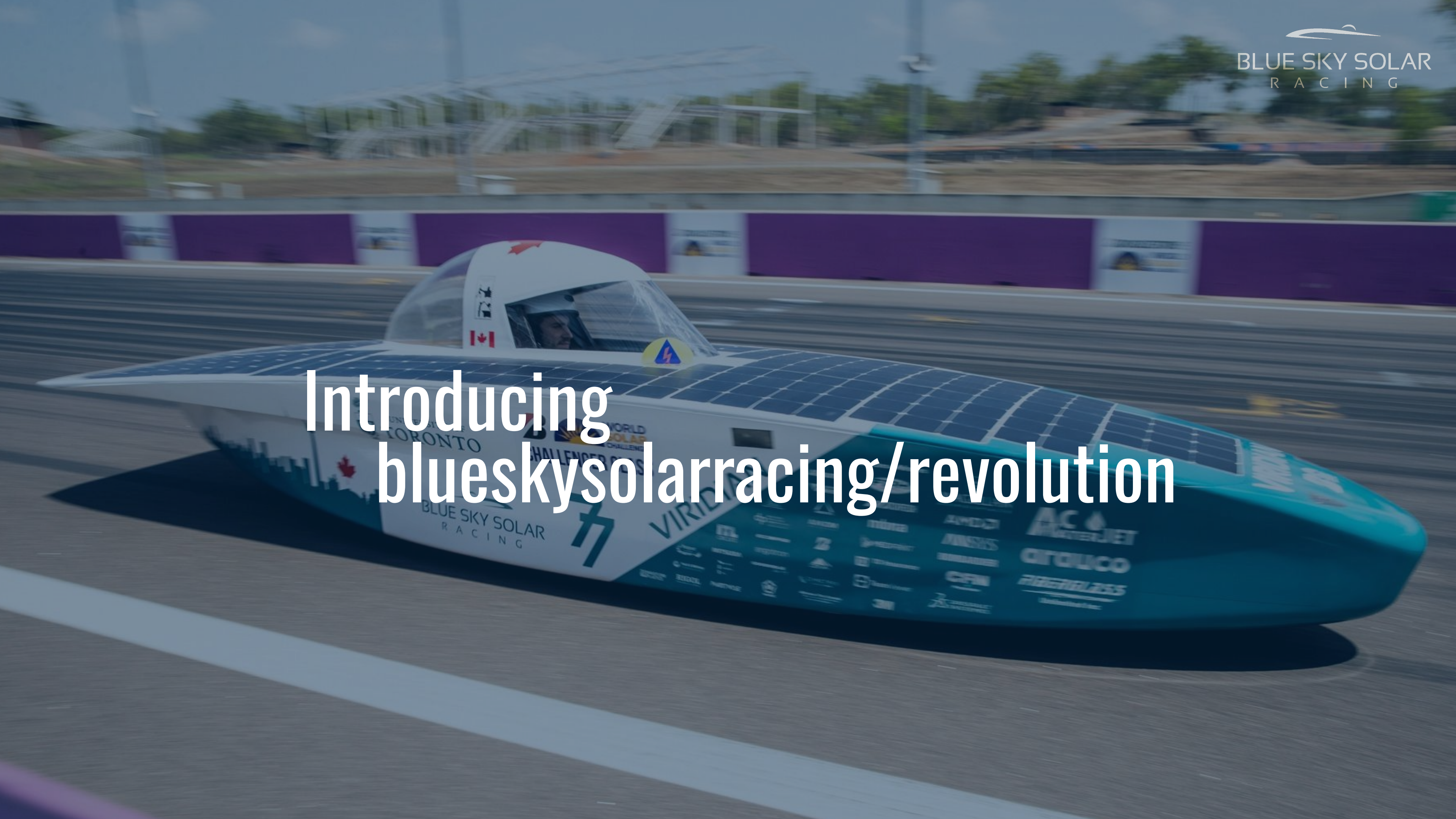
Should Blue Sky make this leap?

Today, we have the momentum



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Introducing blueskysolarracing/revolution

A New Linux Computing Platform

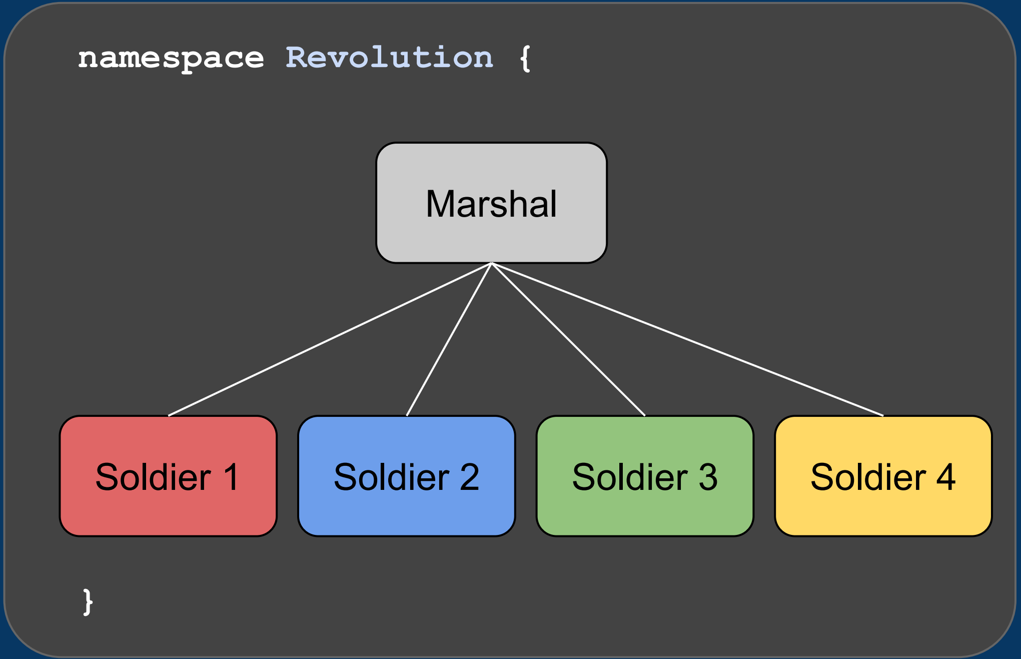
- Remote access
- Powerful
- Well-documented
- Great support

From C to modern C++

- Fast
- C++
  - Low & high level
  - Abstraction/separation
  - STL
  - C compatibility
  - More features

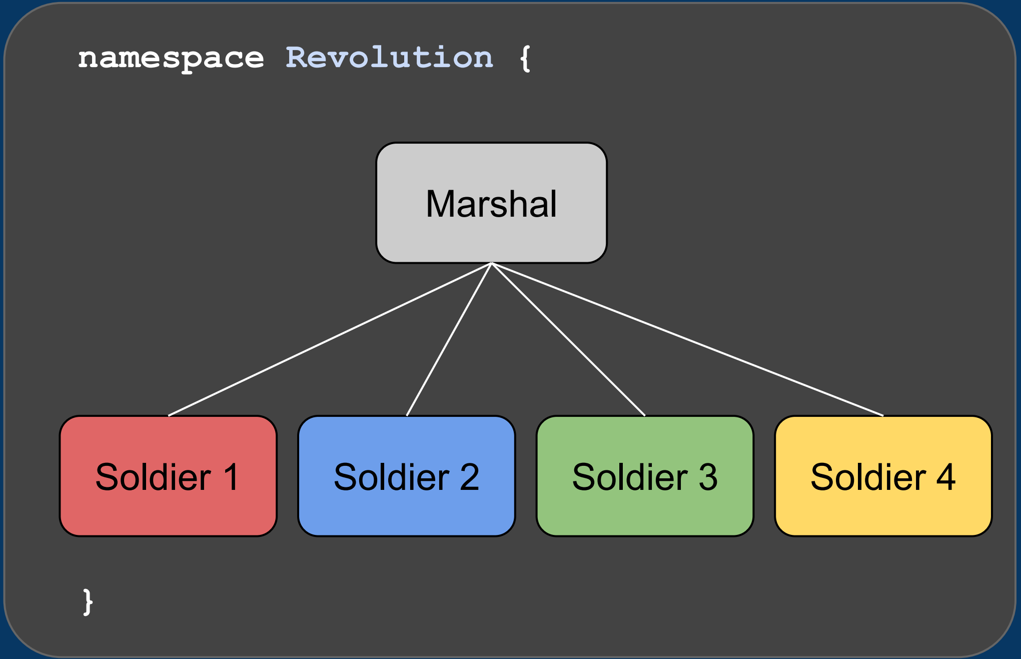
Marshal-Soldier Architecture

- Applications
  - Marshal
    - Syncer
  - Soldiers
    - Display Driver
    - Power Sensor
    - Motor Controller
    - Telemeter
    - And so on…



Car State Synchronization

- Everything on the "same page"
- Writes:
  - Soldiers request marshal
  - Marshal propagates
- Reads:
  - Internal cache
    - Efficiency
    - Marshal may crash



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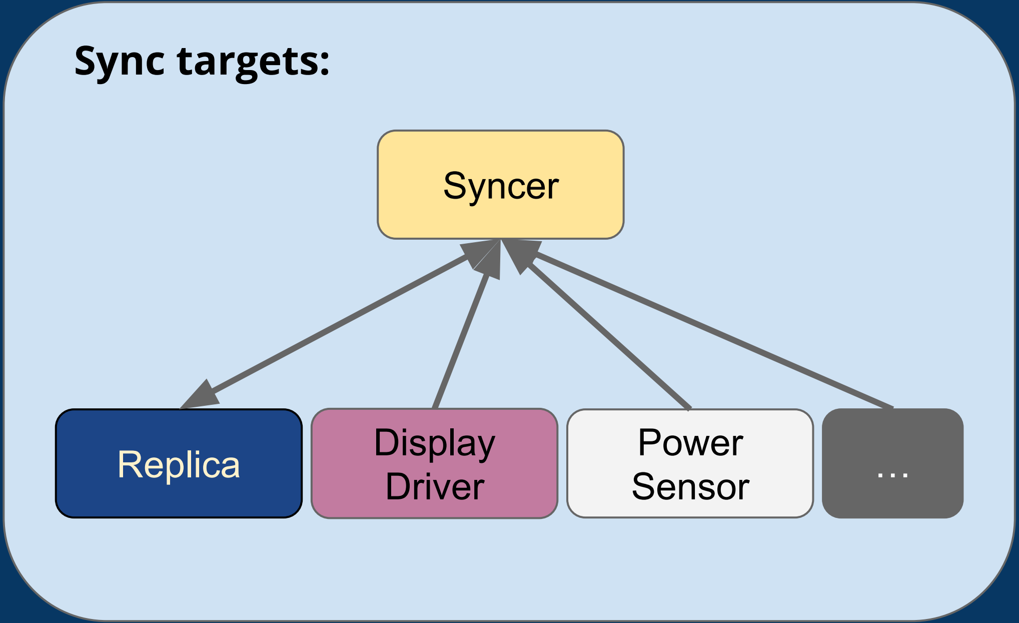
Crash Recovery

- Recover quickly
- Systemd monitors crash
- Data recovery via sync



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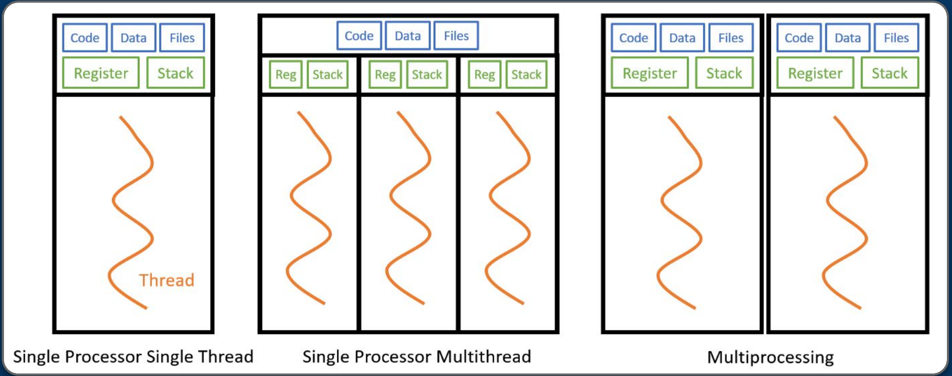
Why Multiprocess?

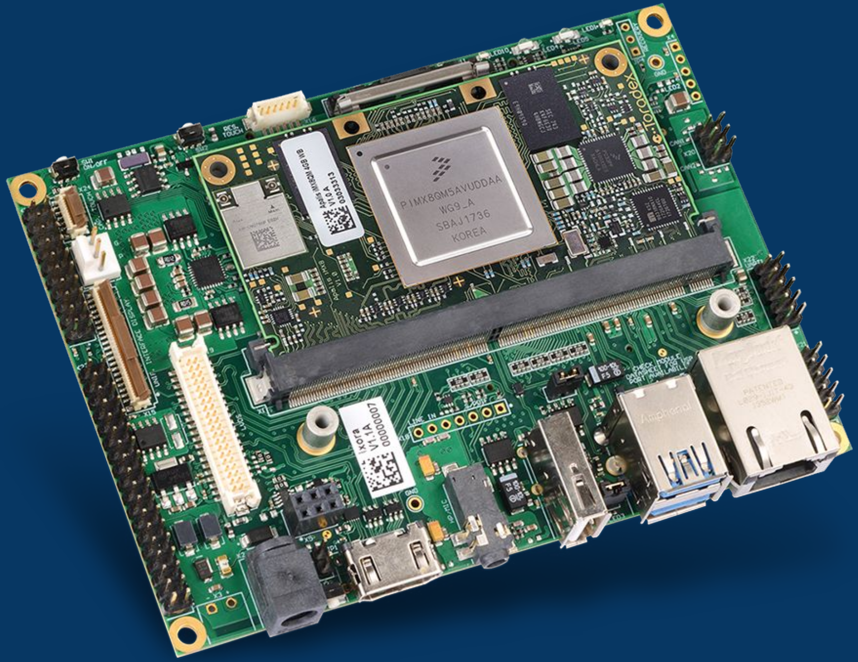
- Multithreading
  - (More) efficient
  - On crash:
    - Complete loss of states
    - Complete loss of control



- Multiprocessing
  - Better logs
  - On crash:
    - Can replicate states from other processes
    - Partial loss of control

Virtual H/W Interface

- Simulate H/W access
- Unit tests



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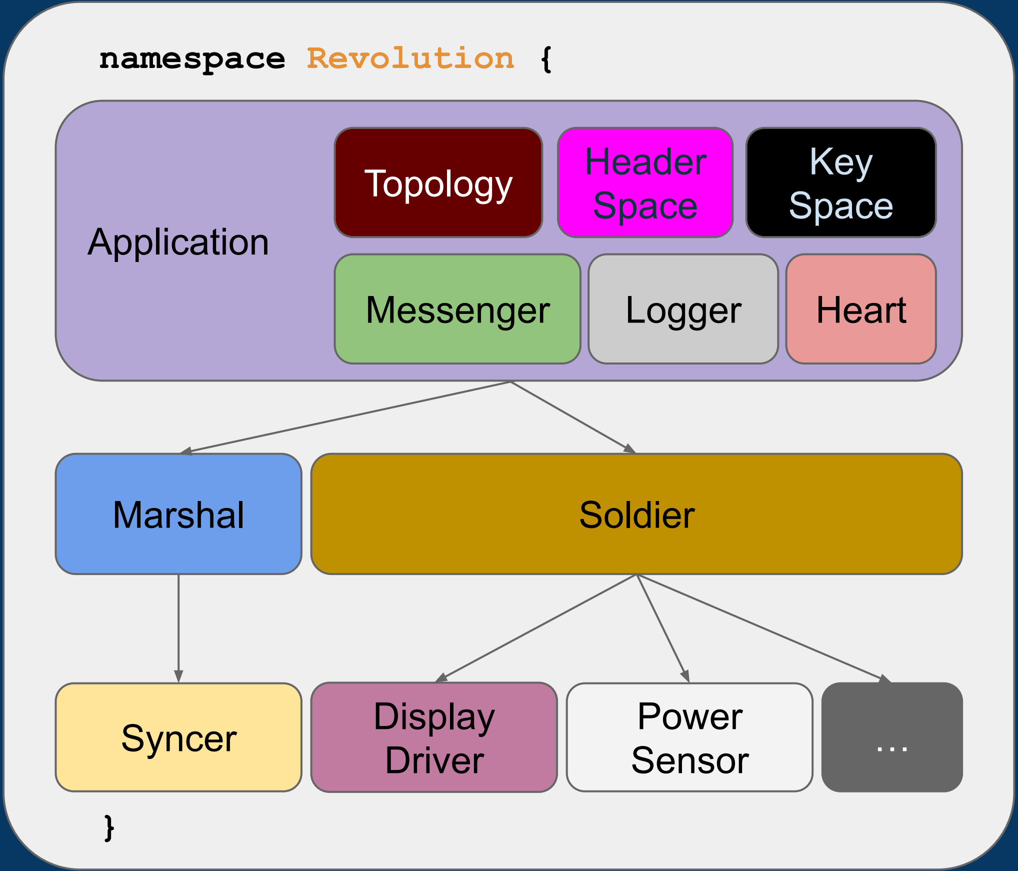
Class Inheritance Map

- Utilities
  - Messenger
  - Logger
  - Heart
  - Client
- Configuration
  - Topology
  - Header space
  - Key space
- Applications
  - Marshal
    - Syncer
  - Soldier
    - Display Driver
    - Power Sensor
    - etc…

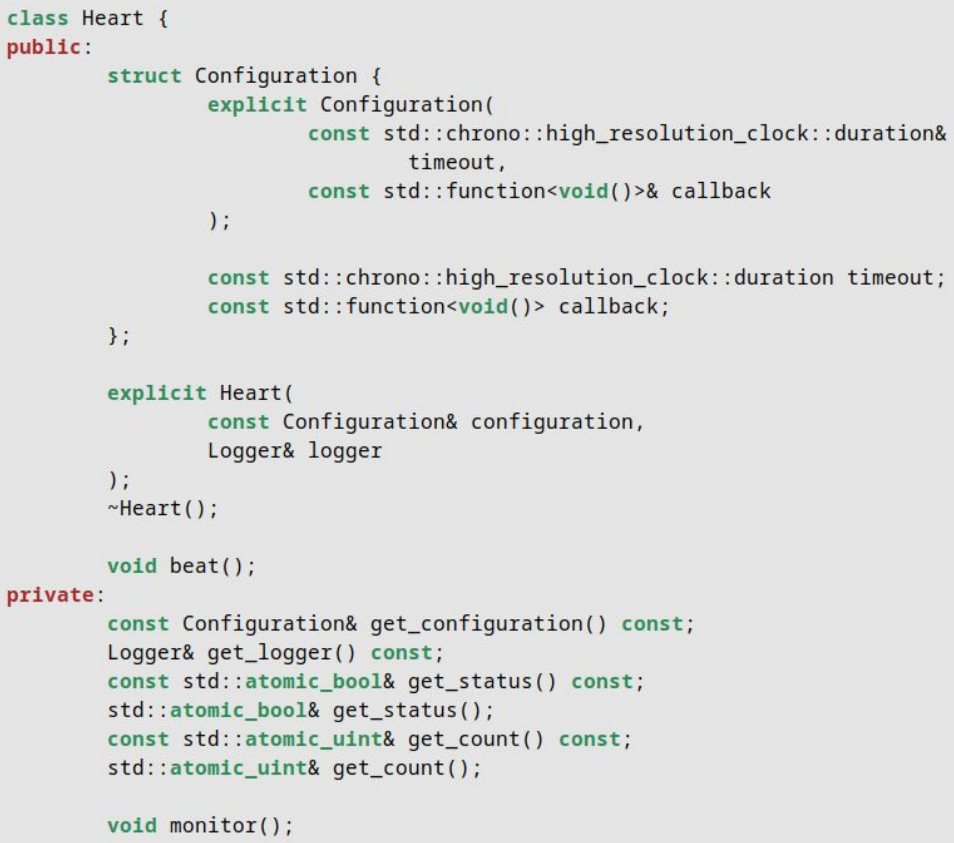


Utilities – Messenger and Logger

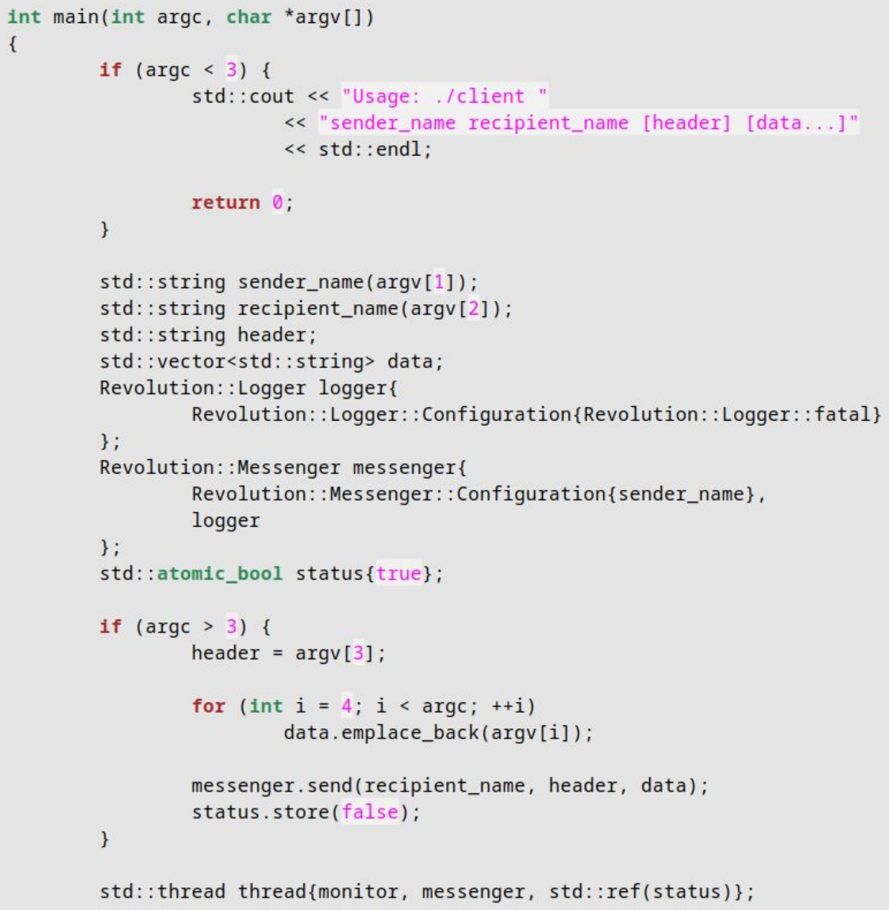
```cpp
class Messenger {
public:
        struct Message {
                static Message deserialize(
                        const std::string& raw_message
                );

                explicit Message(
                        const std::string& sender_name,
                        const std::string& header,
                        const std::vector<std::string>& data = {}
                );

                std::string serialize() const;
                std::string to_string() const;

                const std::string sender_name;
                const std::string header;
                const std::vector<std::string> data;
        };

        struct Configuration {
                explicit Configuration(
                        const std::string& name,
                        const std::string& full_name_prefix = "/",
                        const unsigned int& priority = 0,
                        const int& oflags = O_RDWR | O_CREAT,
                        const mode_t& mode = 0644
                );

                const std::string name;
                const std::string full_name_prefix;
                const unsigned int priority;
                const int oflags;
                const mode_t mode;
```

```cpp
class Logger : public std::ostream {
public:
        struct Severity {
                explicit Severity(
                        const std::string& name,
                        const unsigned int& level
                );

                const std::string name;
                const unsigned int level;
        };

        struct Configuration {
                explicit Configuration(
                        const Severity& severity,
                        const std::string& filename = "",
                        const std::ofstream::openmode& open_mode
                                = std::ofstream::app
                );

                const Severity severity;
                const std::string filename;
                const std::ofstream::openmode open_mode;
        };

        static const Severity trace;
        static const Severity debug;
        static const Severity info;
        static const Severity warning;
        static const Severity error;
        static const Severity fatal;

        explicit Logger(
                const Configuration& configuration
        );
```

Utilities – Heart and Client



```cpp
class Heart {
public:
        struct Configuration {
                explicit Configuration(
                        const std::chrono::high_resolution_clock::duration&
                                timeout,
                        const std::function<void()>& callback
                );

                const std::chrono::high_resolution_clock::duration timeout;
                const std::function<void()> callback;
        };

        explicit Heart(
                const Configuration& configuration,
                Logger& logger
        );
        ~Heart();

        void beat();
private:
        const Configuration& get_configuration() const;
        Logger& get_logger() const;
        const std::atomic_bool& get_status() const;
        std::atomic_bool& get_status();
        const std::atomic_uint& get_count() const;
        std::atomic_uint& get_count();

        void monitor();
```



```cpp
int main(int argc, char *argv[])
{
        if (argc < 3) {
                std::cout << "Usage: ./client "
                        << "sender_name recipient_name [header] [data...]"
                        << std::endl;

                return 0;
        }

        std::string sender_name(argv[1]);
        std::string recipient_name(argv[2]);
        std::string header;
        std::vector<std::string> data;
        Revolution::Logger logger{
                Revolution::Logger::Configuration{Revolution::Logger::fatal}
        };
        Revolution::Messenger messenger{
                Revolution::Messenger::Configuration{sender_name},
                logger
        };
        std::atomic_bool status{true};

        if (argc > 3) {
                header = argv[3];

                for (int i = 4; i < argc; ++i)
                        data.emplace_back(argv[i]);

                messenger.send(recipient_name, header, data);
                status.store(false);
        }

        std::thread thread{monitor, messenger, std::ref(status)};
```

Configuration – Topology, Header/Key Space

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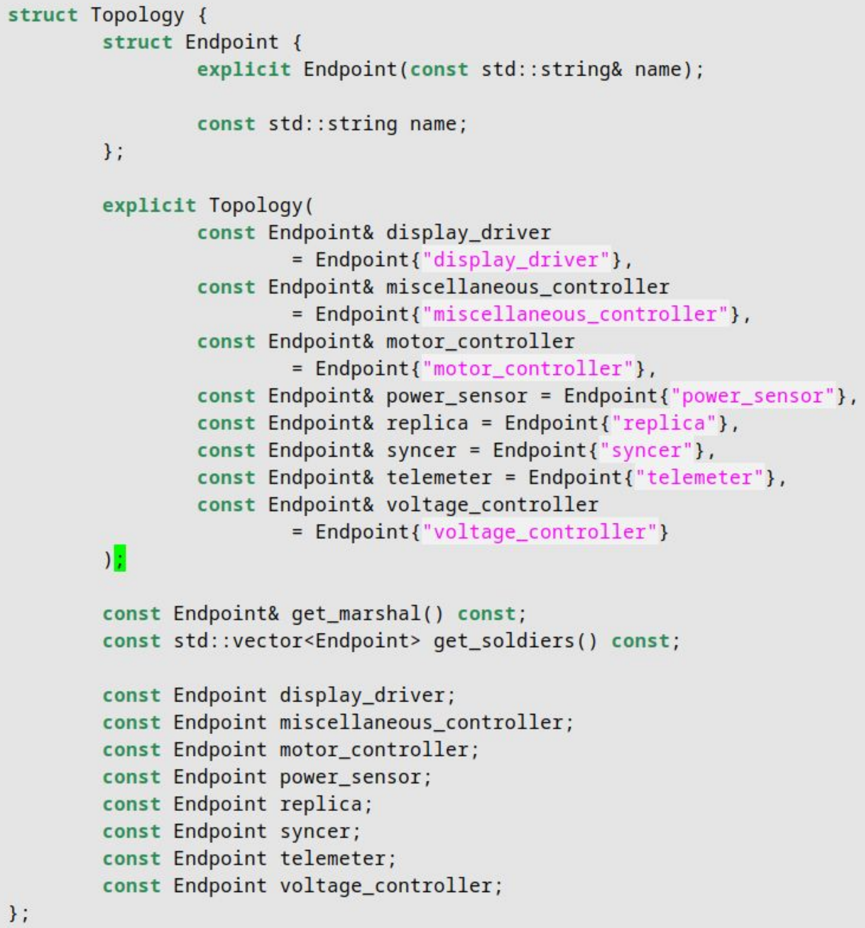


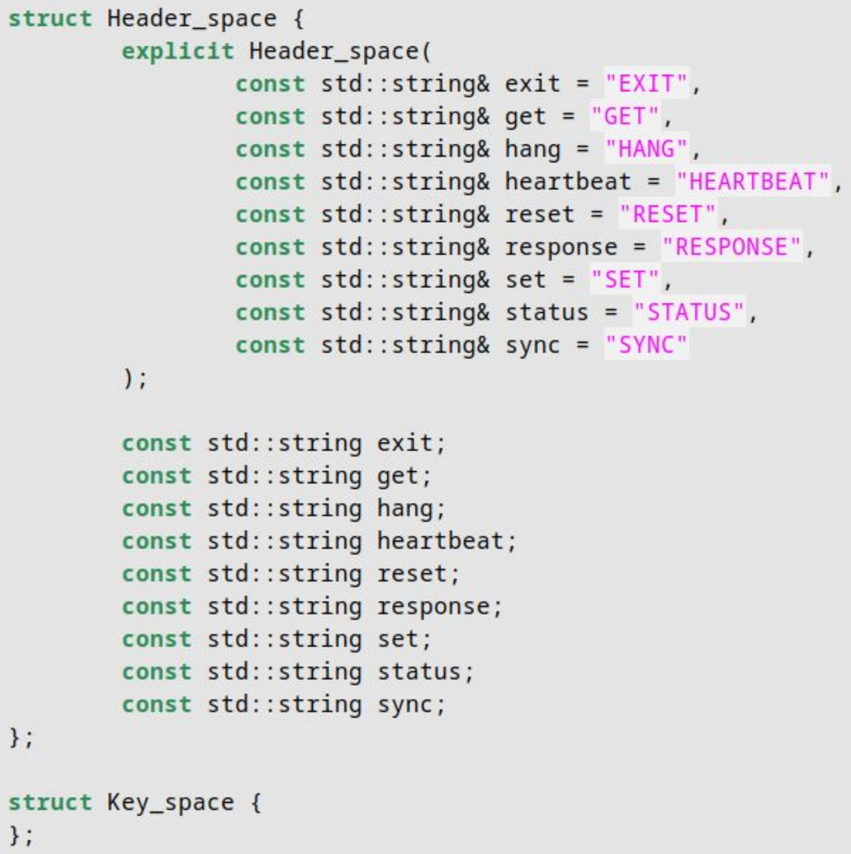
```
struct Topology {
        struct Endpoint {
                explicit Endpoint(const std::string& name);

                const std::string name;
        };

        explicit Topology(
                const Endpoint& display_driver
                        = Endpoint{"display_driver"},
                const Endpoint& miscellaneous_controller
                        = Endpoint{"miscellaneous_controller"},
                const Endpoint& motor_controller
                        = Endpoint{"motor_controller"},
                const Endpoint& power_sensor = Endpoint{"power_sensor"},
                const Endpoint& replica = Endpoint{"replica"},
                const Endpoint& syncer = Endpoint{"syncer"},
                const Endpoint& telemeter = Endpoint{"telemeter"},
                const Endpoint& voltage_controller
                        = Endpoint{"voltage_controller"}
        );

        const Endpoint& get_marshal() const;
        const std::vector<Endpoint> get_soldiers() const;

        const Endpoint display_driver;
        const Endpoint miscellaneous_controller;
        const Endpoint motor_controller;
        const Endpoint power_sensor;
        const Endpoint replica;
        const Endpoint syncer;
        const Endpoint telemeter;
        const Endpoint voltage_controller;
};
```



```
struct Header_space {
        explicit Header_space(
                const std::string& exit = "EXIT",
                const std::string& get = "GET",
                const std::string& hang = "HANG",
                const std::string& heartbeat = "HEARTBEAT",
                const std::string& reset = "RESET",
                const std::string& response = "RESPONSE",
                const std::string& set = "SET",
                const std::string& status = "STATUS",
                const std::string& sync = "SYNC"
        );

        const std::string exit;
        const std::string get;
        const std::string hang;
        const std::string heartbeat;
        const std::string reset;
        const std::string response;
        const std::string set;
        const std::string status;
        const std::string sync;
};

struct Key_space {
};
```

Applications – Marshal and Soldier

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```
class Application {
public:
    using Handler = std::function<void(const Messenger::Message&)>;
    using Handlers = std::unordered_map<std::string, Handler>;
    using States = std::unordered_map<std::string, std::string>;

    explicit Application(
        const Topology& topology,
        const Header_space& header_space,
        const Key_space& key_space,
        Logger& logger,
        const Messenger& messenger,
        Heart& heart
    );

    virtual void run();
protected:
    const Topology& get_topology() const;
    const Header_space& get_header_space() const;
    const Key_space& get_key_space() const;
    Logger& get_logger() const;
    const Messenger& get_messenger() const;
    Heart& get_heart() const;
    const bool& get_status() const;
    void set_status(const bool& status);
    const States& get_states() const;
    std::vector<std::string> get_state_data() const;
    void set_handler(
        const std::string& name,
        const Handler& handler
    );
    virtual const Topology::Endpoint& get_endpoint() const = 0;

    void handle_exit(const Messenger::Message& message);
    void handle_hang(const Messenger::Message& message) const;
```

```
class Marshal : public Application {
public:
    explicit Marshal(
        const Topology& topology,
        const Header_space& header_space,
        const Key_space& key_space,
        Logger& logger,
        const Messenger& messenger,
        Heart& heart
    );

    void run() override;
protected:
    void handle_write(const Messenger::Message& message) override;
};
```

```
class Soldier : public Application {
public:
    explicit Soldier(
        const Topology& topology,
        const Header_space& header_space,
        const Key_space& key_space,
        Logger& logger,
        const Messenger& messenger,
        Heart& heart
    );

    void run() override;
protected:
    void handle_write(const Messenger::Message& message) override;
};
```

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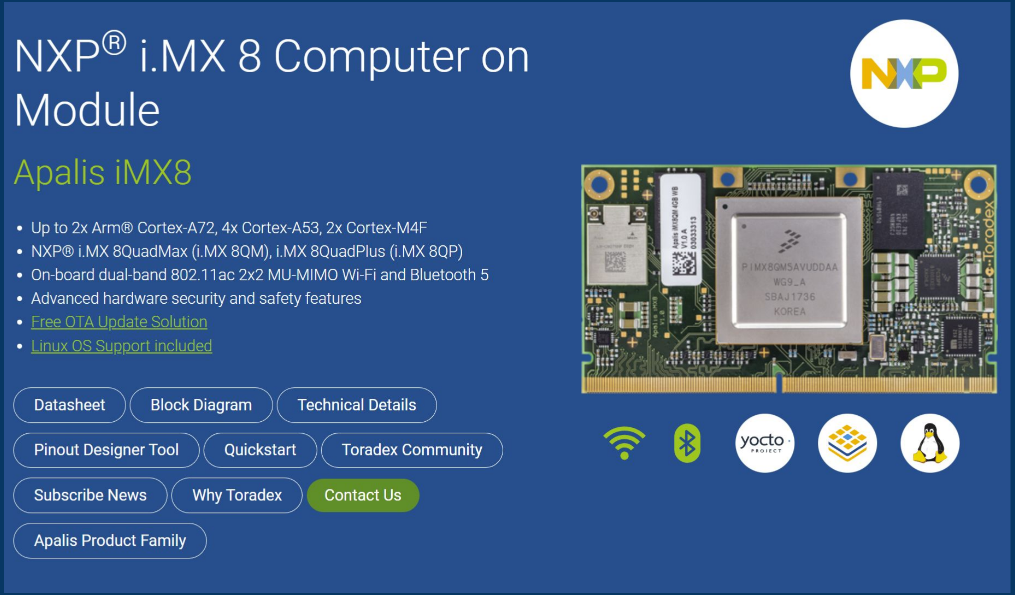
Demo

- Setup and startup
- State propagation
- Crash recovery

Going forward as a team

- Obtain board
- Implement HW interface
  - GPIO, SPI, I2C
  - Complete by end of year
- Implement soldiers
  - Display
  - Motor
  - Battery
  - Telemetry
  - Driver
- Complete software by April



NXP® i.MX 8 Computer on Module

Apalis iMX8

- Up to 2x Arm® Cortex-A72, 4x Cortex-A53, 2x Cortex-M4F
- NXP® i.MX 8QuadMax (i.MX 8QM), i.MX 8QuadPlus (i.MX 8QP)
- On-board dual-band 802.11ac 2x2 MU-MIMO Wi-Fi and Bluetooth 5
- Advanced hardware security and safety features
- Free OTA Update Solution
- Linux OS Support included

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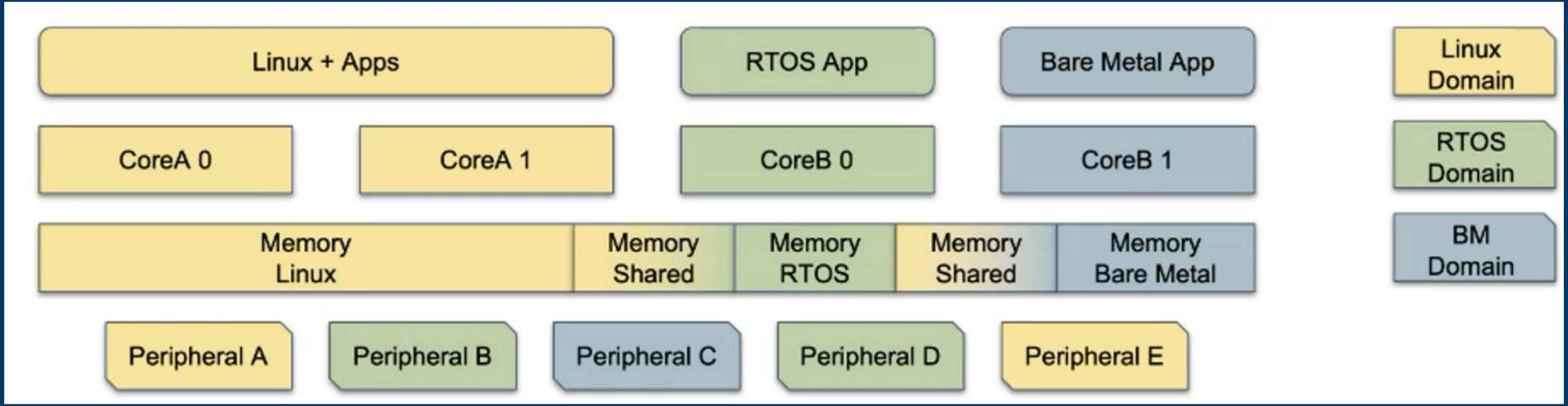
Our End Goal

- Successful Implementation of Heterogeneous Compute
  - Fulfill Real-Time requirements, while having powerful processing capabilities



Blue Sky is a not just a design team

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Blue Sky is a Revolution

Visit us at:
https://github.com/blueskysolarracing/revolution