Understanding µProcessors

A Startup Based Approach

IoT System Design

Startup's Objectives

- Education: Making people more knowledgeable / skilled
  - Schools, Training institutes
- Retail stores: Making goods available at certain place
  - Malls, Neighborhood general store
- Manufacturing: Translating raw material into finished goods
  - IC / PCB manufacturers, Automakers
- Services: Enhancing experience,
  - Education, Travel & tourism, Hospitality, Banking, Healthcare, Security

Startup's Objectives

- Education: Making people more knowledgeable / skilled
  - Schools, Training institutes
- Retail stores: Making goods available at certain place
  - Malls, Neighborhood general store
- Manufacturing: Translating raw material into finished goods
  - IC / PCB manufacturers, Automakers
- Services: Enhancing experience,
  - Education, Travel & tourism, Hospitality, Banking, Healthcare, Security

For what kind of application you'll be using Microprocessor?

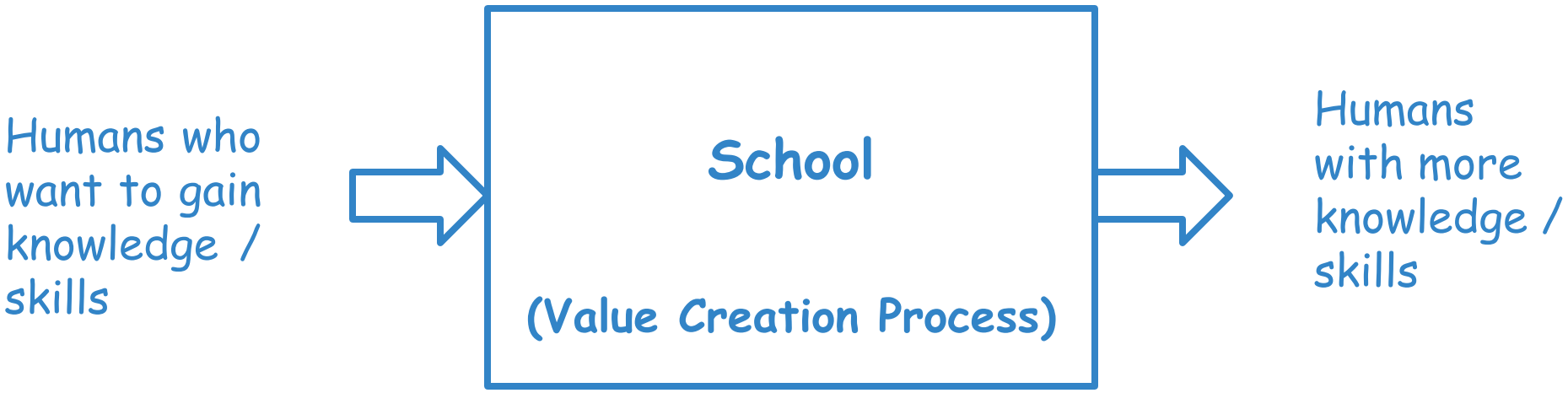
An Organization

Key Resources
- Resource1
- Resource2
- Resource3

Organizational structure and value creation process depends on the application

Choice of Microprocessors's architecture and its f/w depends upon application

Education

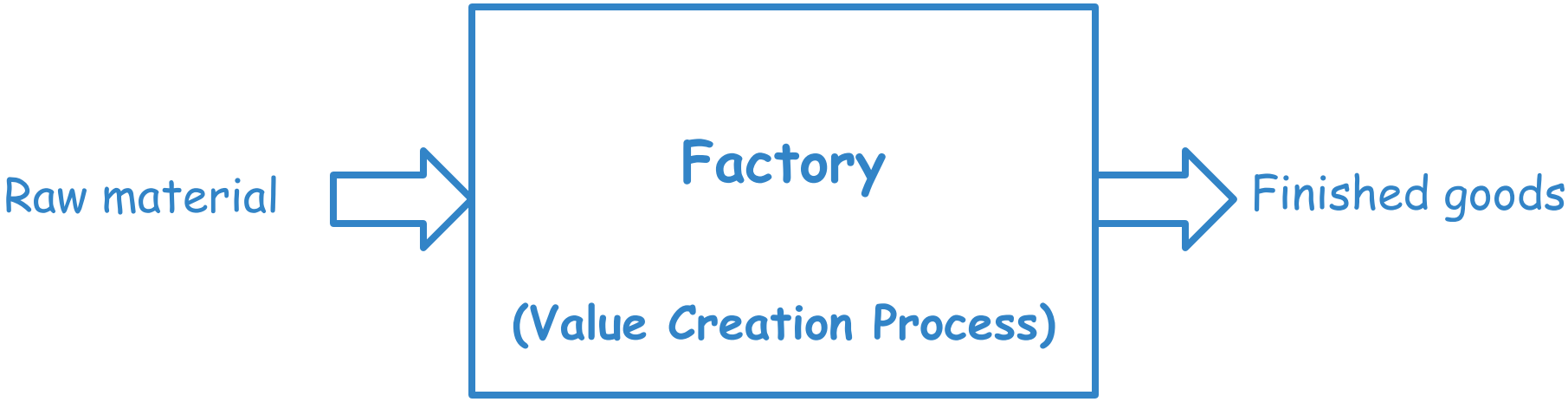


Resources
- Teachers
- Infrastructure (Classes, Lab)
- Processes

Organizational structure and value creation process depends on the application

Choice of Microprocessors's architecture and its f/w depends upon application

Manufacturing



Resources
- Machines
- Humans
- Processes

Organizational structure and value creation process depends on the application

Choice of Microprocessors's architecture and its f/w depends upon application

Retail

Resources
- Place
- Humans
- Processes

Organizational structure and value creation process depends on the application

Choice of Microprocessors's architecture and its f/w depends upon application

Necessary Ingredients of a Startup

- A Key Person with core expertise (Could be multiple also)
- Basic infrastructure
  - Space,
  - Furniture (table, chair, clock)
  - Office stationary (notebook, pen etc)
  - Utilities (power, water etc)
  - Storage space (cabinets for files, warehouses for raw material)
  - Connectivity with external world (Telephone, internet, video conf)

Necessary Ingredients of a Startup

- A Key Person with core expertise (Could be multiple also)
- Basic infrastructure
  - Space,
  - Furniture (table, chair, clock)
  - Office stationary (notebook, pen etc)
  - Utilities (power, water etc)
  - Storage space (cabinets for files, warehouses for raw material)
  - Connectivity with external world (Telephone, internet, video conf)
- Machines
  - PC / Laptop
  - Equipment, M/f machine etc

Necessary Ingredients of a Startup

- A Key Person with core expertise
- Basic infrastructure
  - Space,
  - Furniture (table, chair, clock)
  - Office stationary (notebook, pen etc)
  - Utilities (power, water etc)
  - Storage space (cabinets for files, warehouses for raw material)
  - Connectivity with external world (Telephone, internet, video conf)
- Machines
  - PC / Laptop
  - Equipment, M/f machine etc
- $$

Basic constituents of a Microprocessor: "A CPU", Basic bldng blocks (like Direct Mem Access, Registers, RAM, Timers, Phased Locked Loops etc), Some accelerators (say for image/video processing etc) and power & clock cycles.

Necessary Ingredients of a Startup

- A Key Person
  - Skills + Time
- Physical Resources
  - To support meeting the objective
- Money
  - To allow adding resources for normal operation and growth

Necessary Ingredients of a Startup

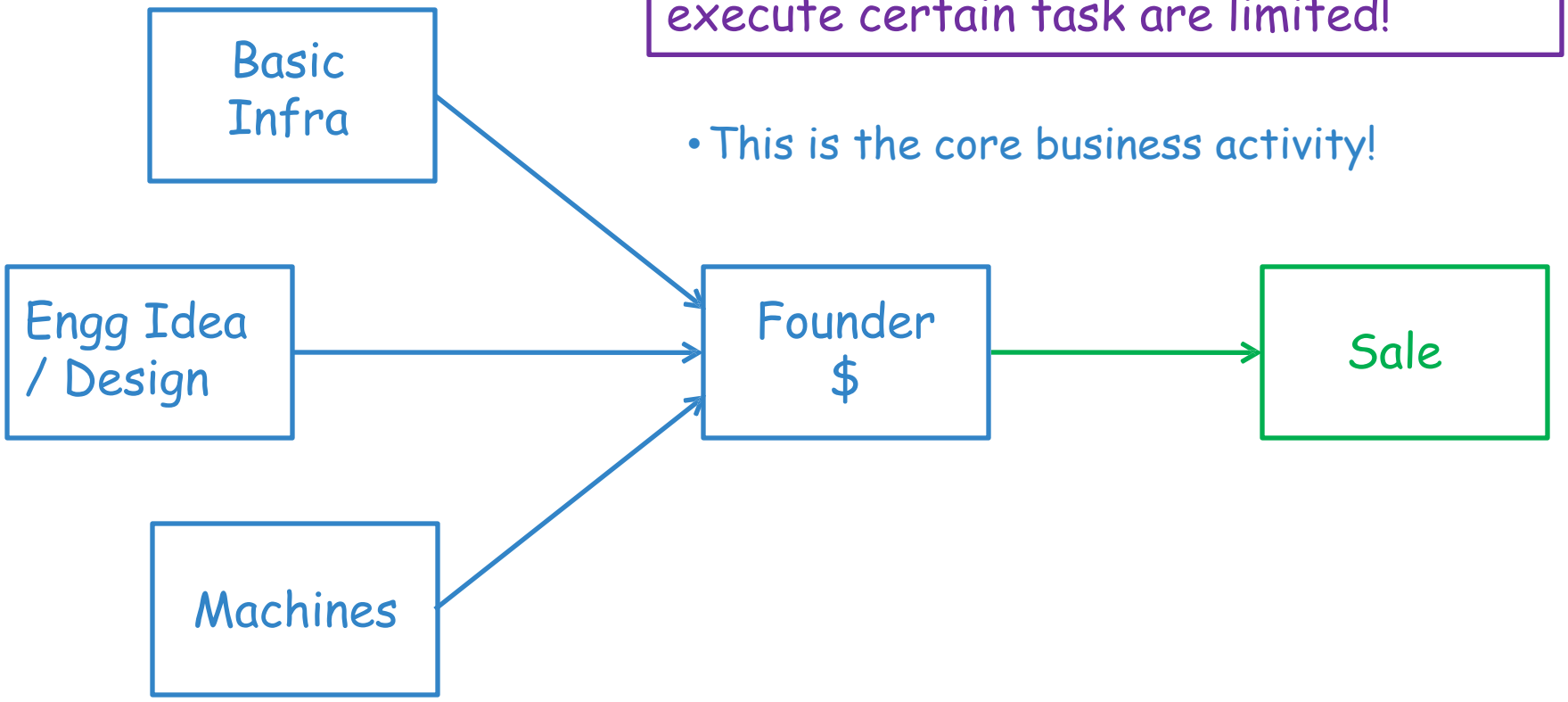
- A Key Person
  - Skills + Time
- Physical Resources
  - To support meeting the objective
- Money
  - To allow adding resources for normal operation and growth

Basic constituents of a Microprocessor:
- Central Processing Unit (CPU)
- Building blocks
- Clock cycles & Power consumption

Basic Structure of a Startup

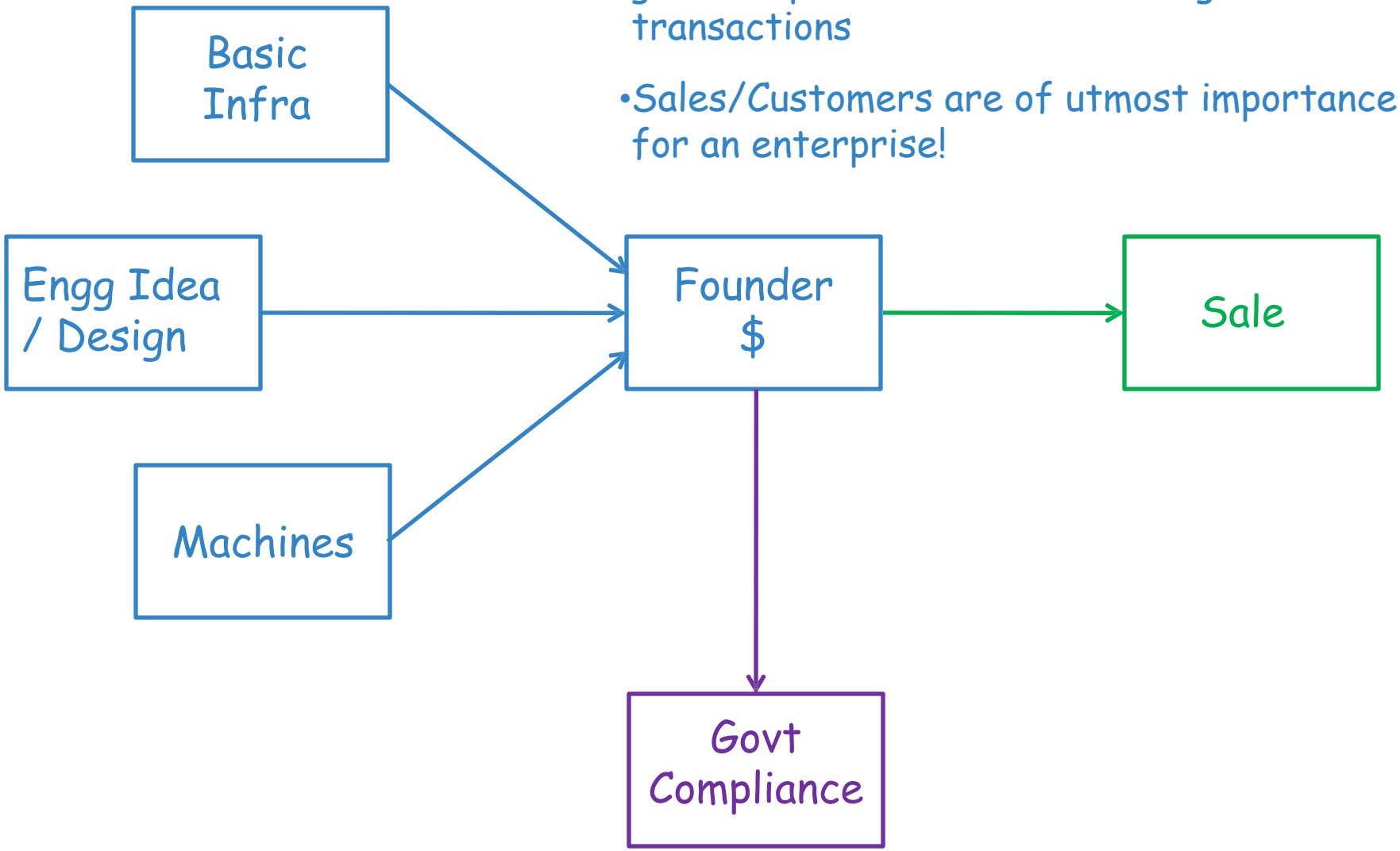
Founders time and CPUs clock cycles to execute certain task are limited!

- This is the core business activity!

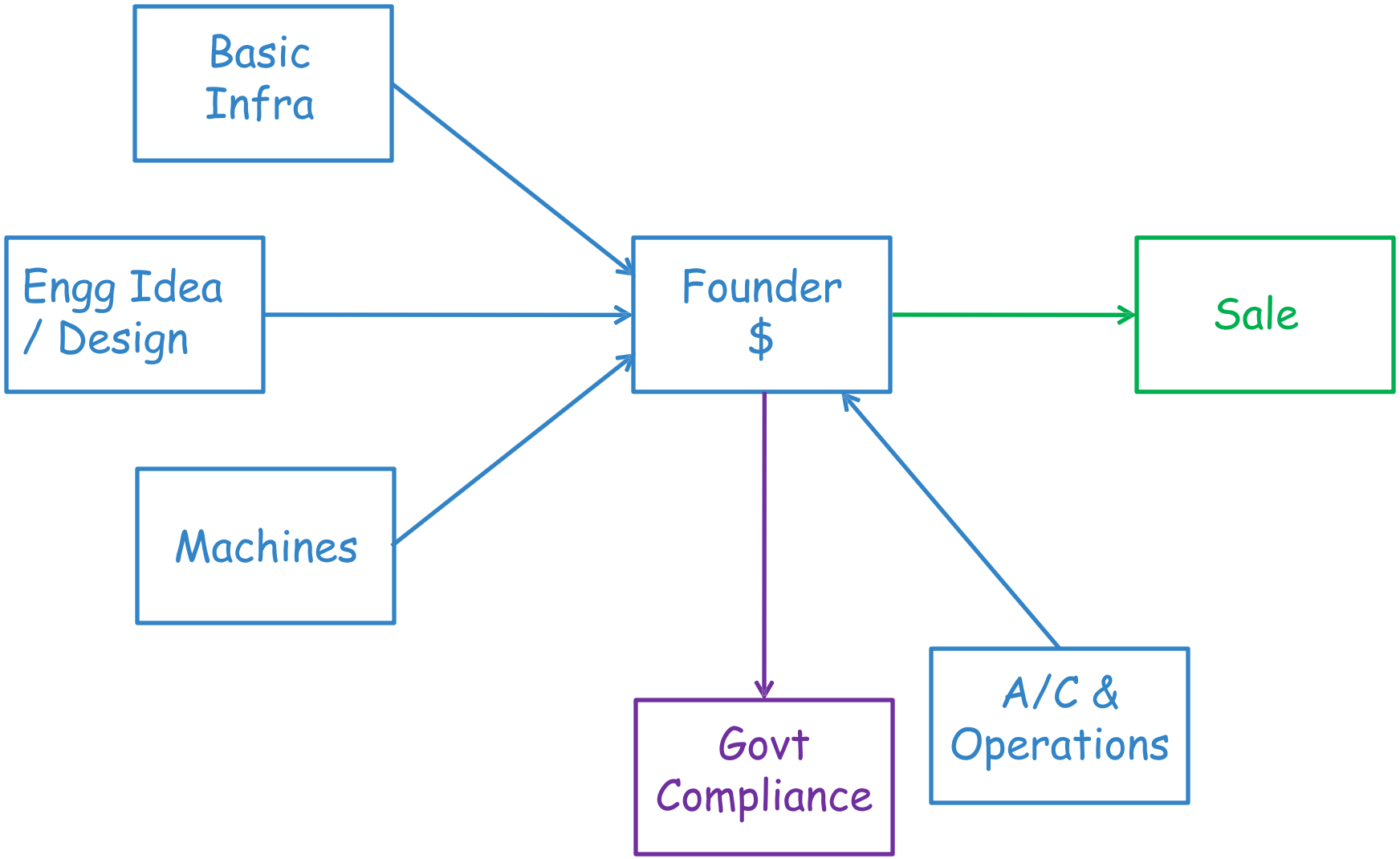


Basic Structure of a Startup

- A business entity needs to follow certain govt compliances before starting commercial transactions
- Sales/Customers are of utmost importance for an enterprise!

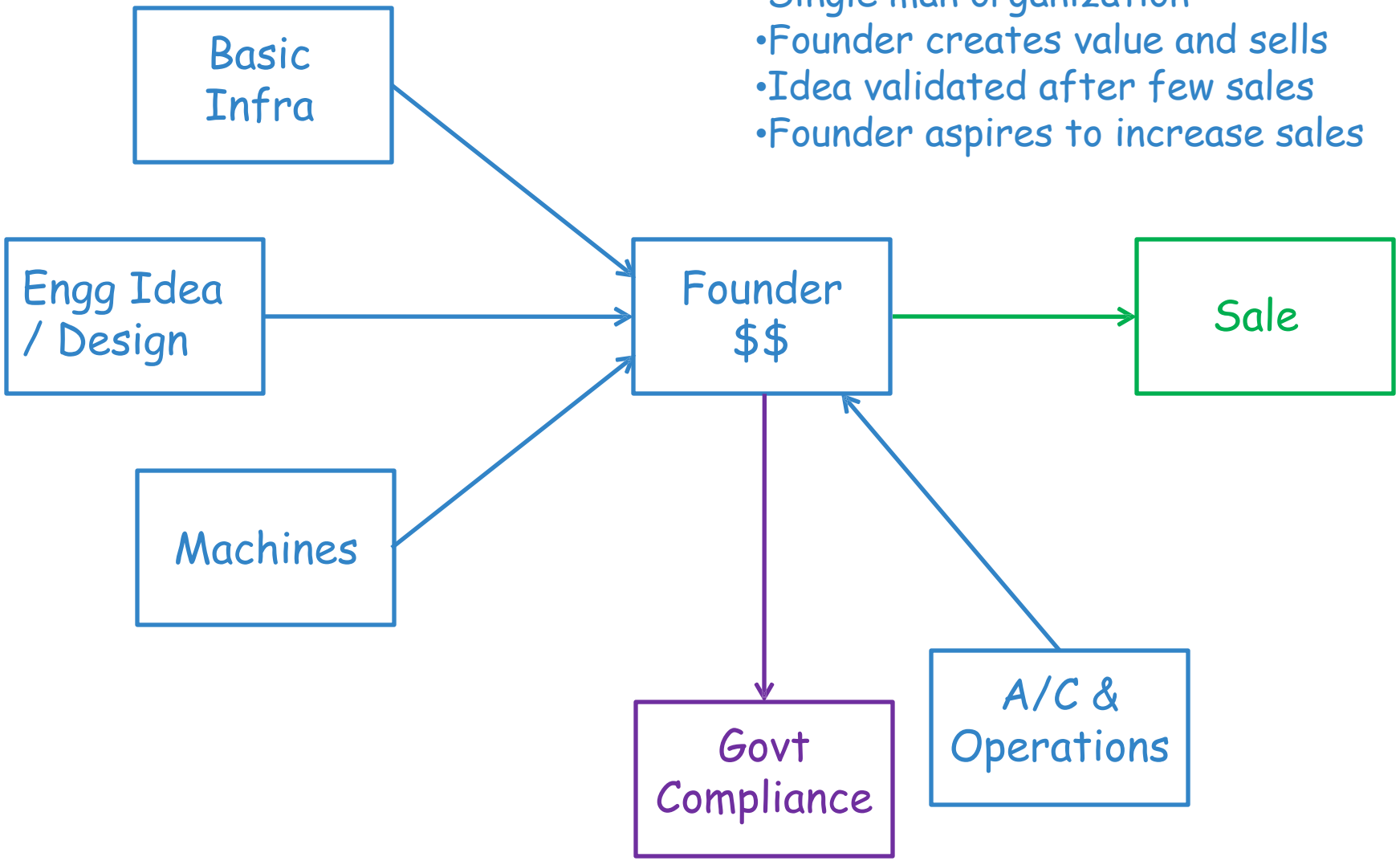


Basic Structure of a Startup



Basic Structure of a Startup

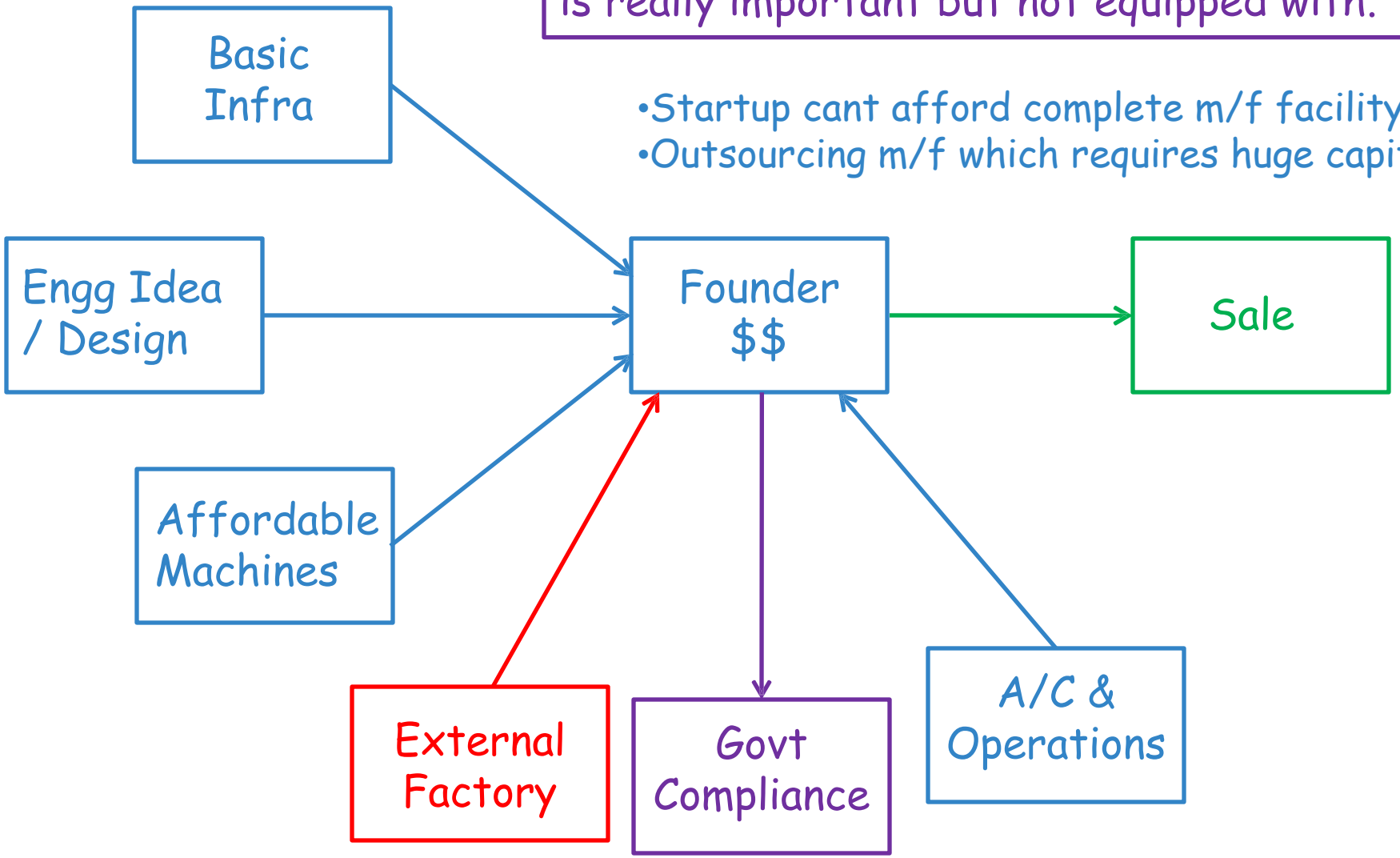
- Single founder startup
- Single man organization
- Founder creates value and sells
- Idea validated after few sales
- Founder aspires to increase sales



Basic Structure of a Startup

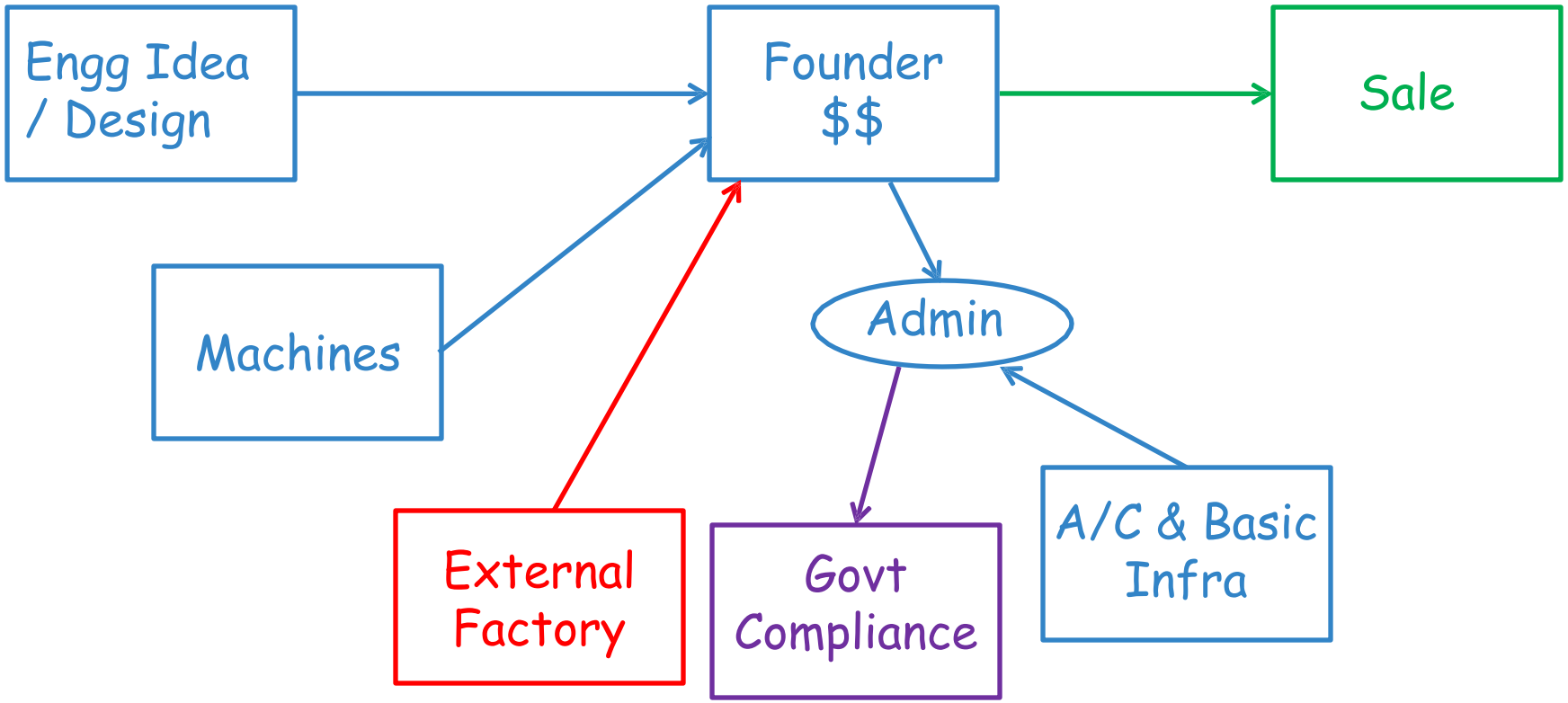
uProcessor would use external module which is really important but not equipped with.

- Startup cant afford complete m/f facility
- Outsourcing m/f which requires huge capital



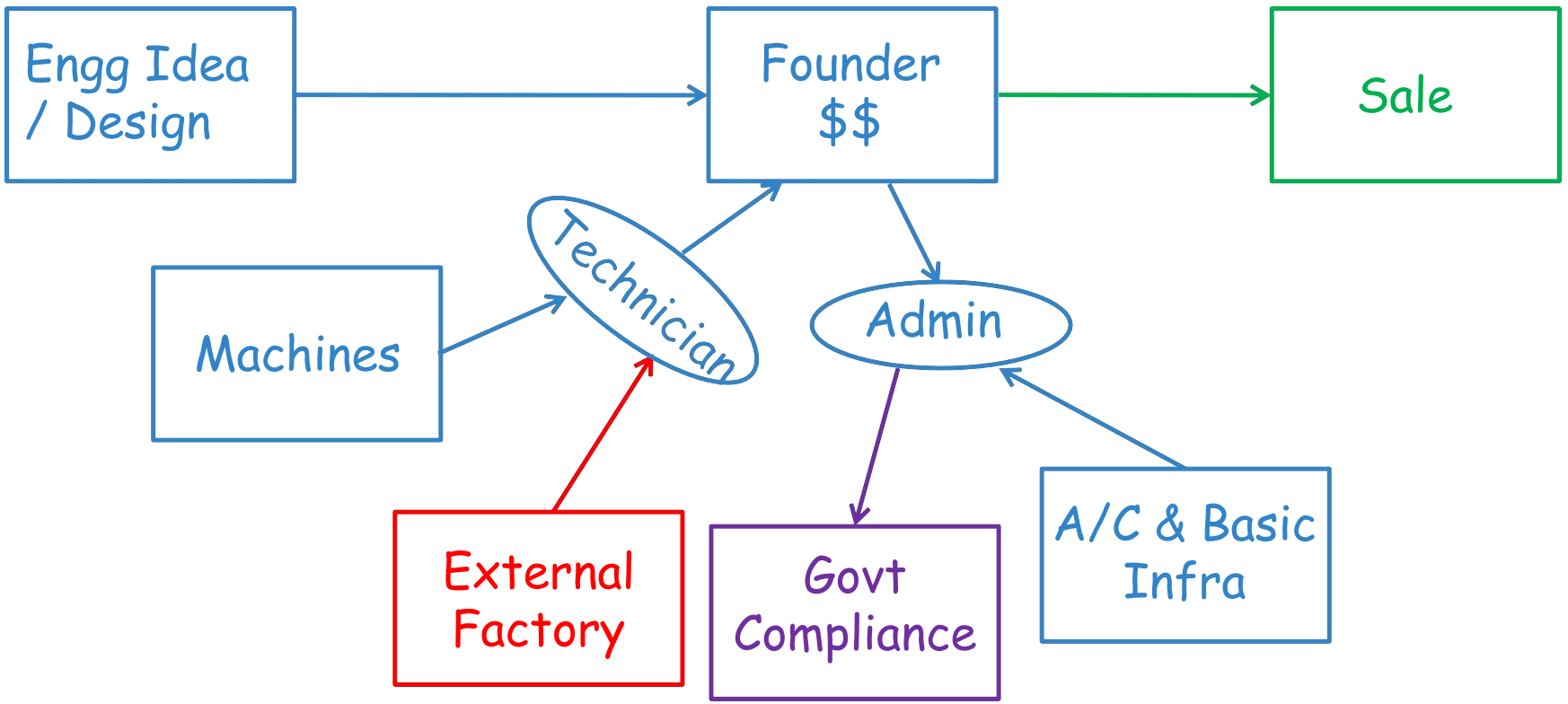
Basic Structure of a Startup

Typically the least important task is delegated first. Most important task is always executed by the Founder / CPU.



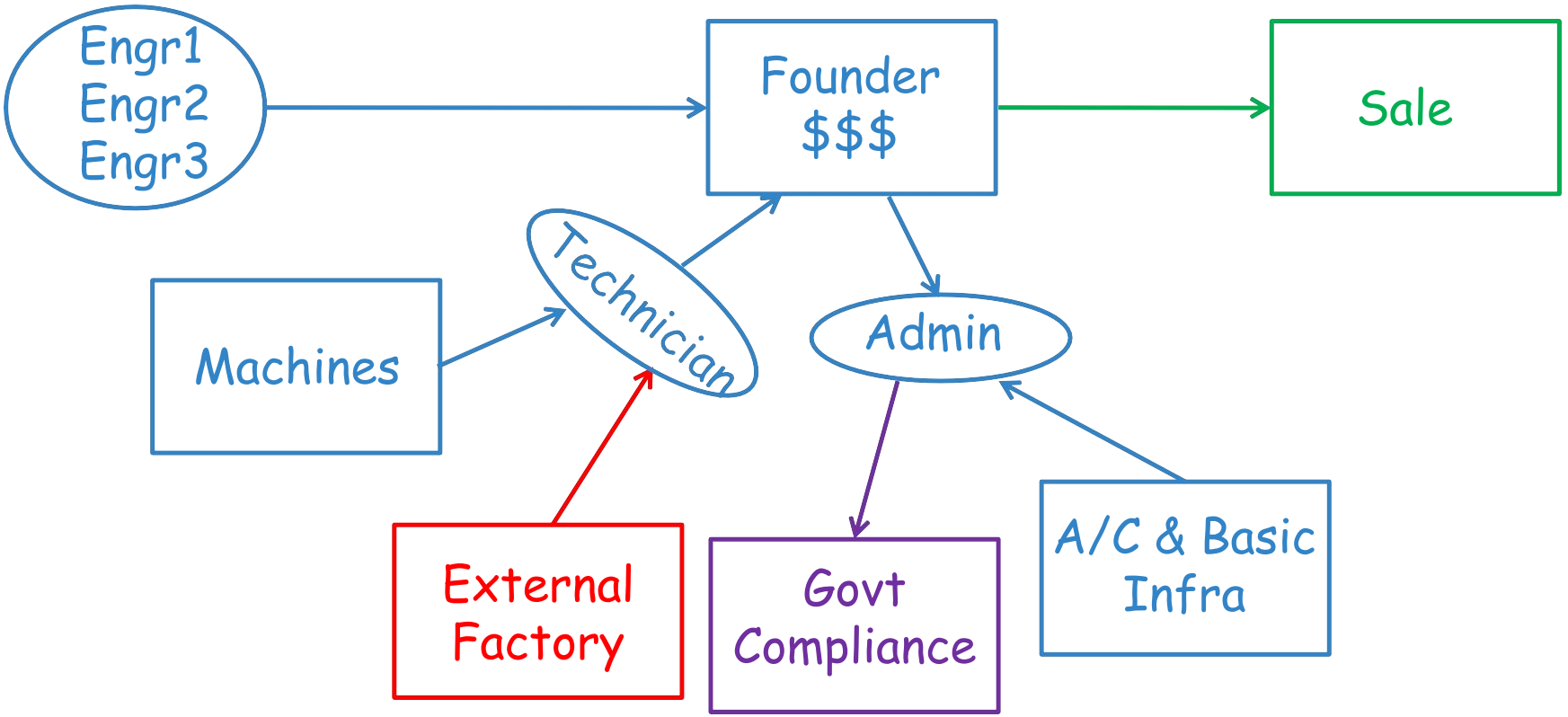
Basic Structure of a Startup

Founder / CPU may not want to loose time in interacting with external technician / hardware (memory/ext modules).



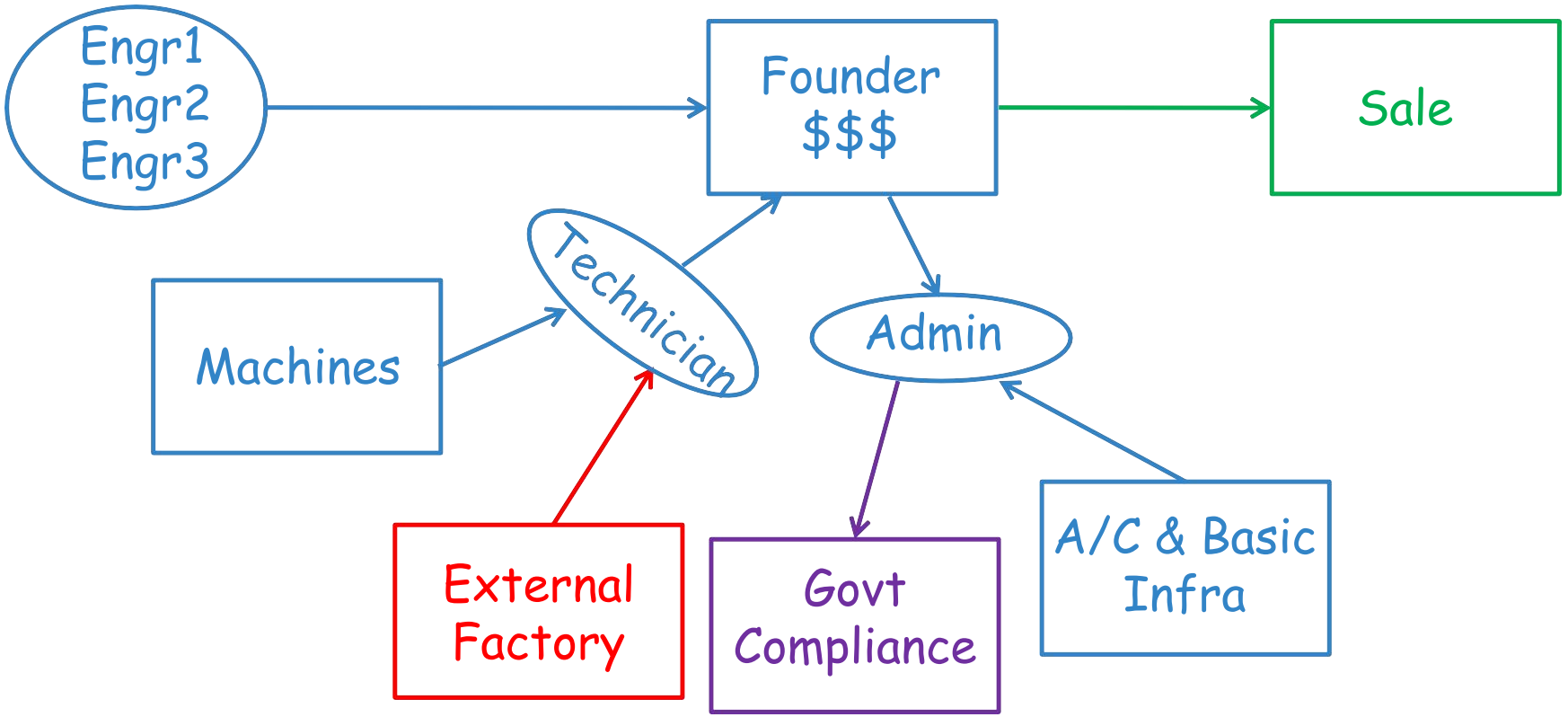
Basic Structure of a Startup

So Founder / CPU appoints a dedicated person / DMA (or I2C, UART, SPI modules) for that purpose.

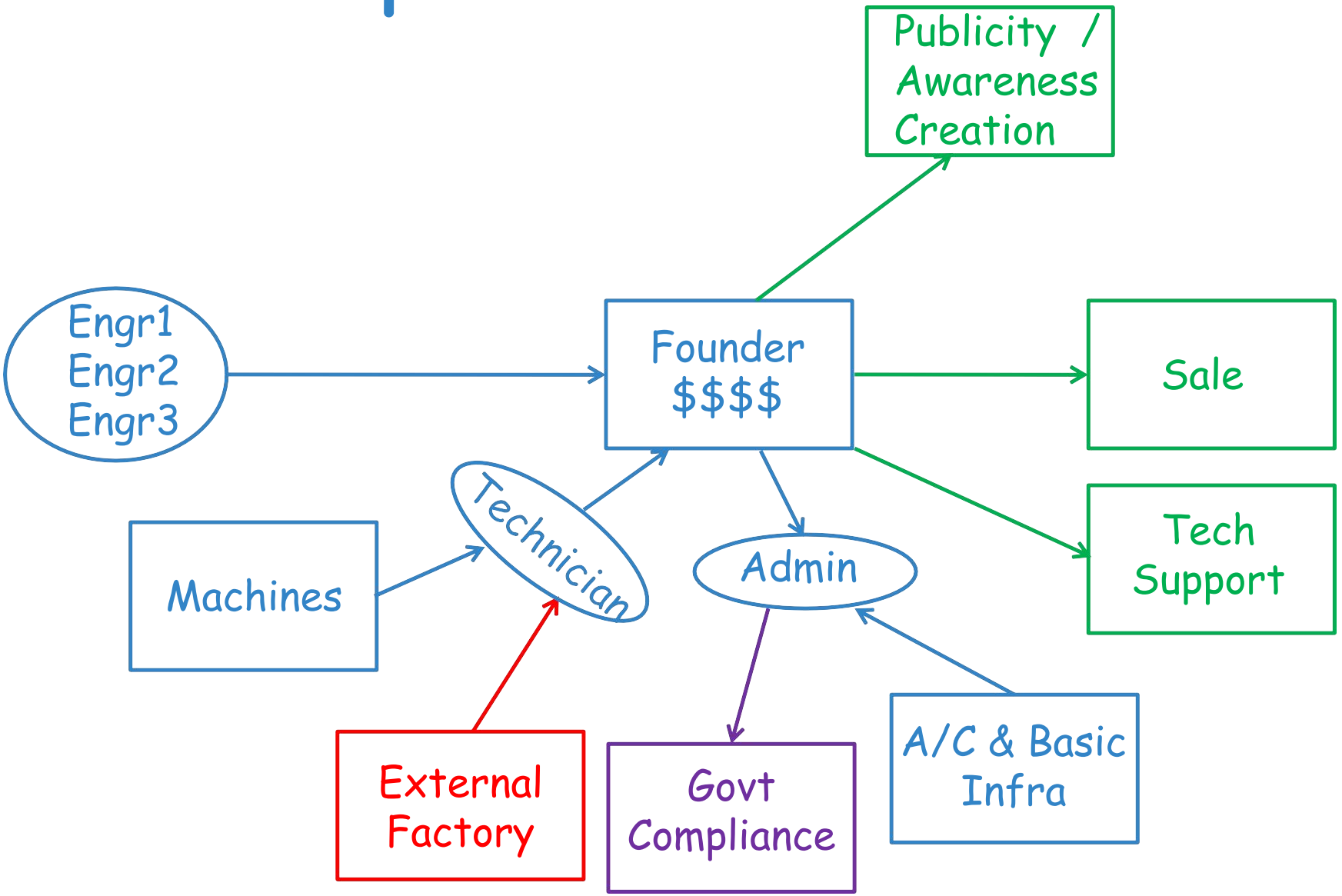


Basic Structure of a Startup

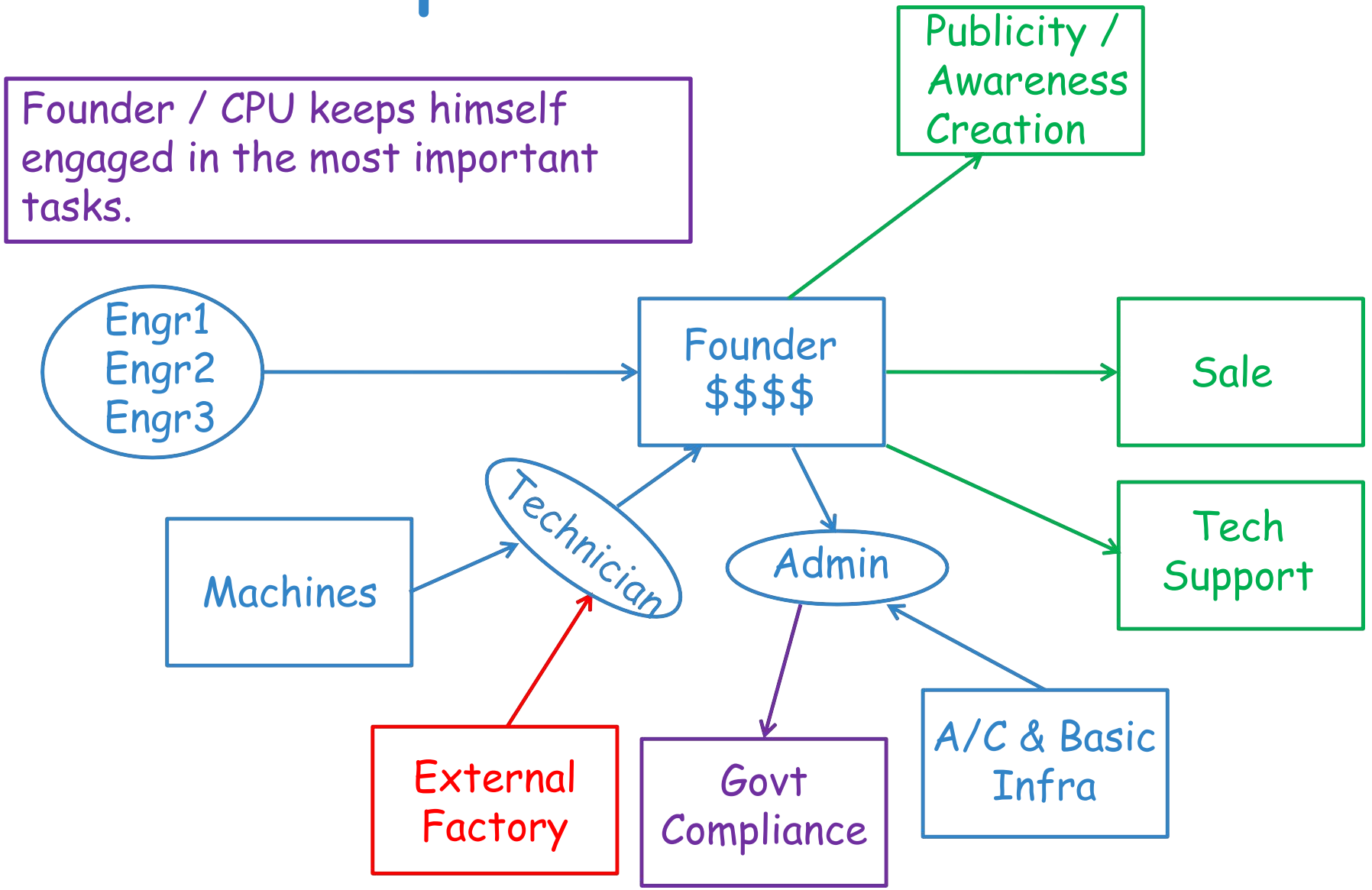
At times Founder and CPU lack certain skillset which can be fulfilled by other resources.



Basic Structure of a Startup

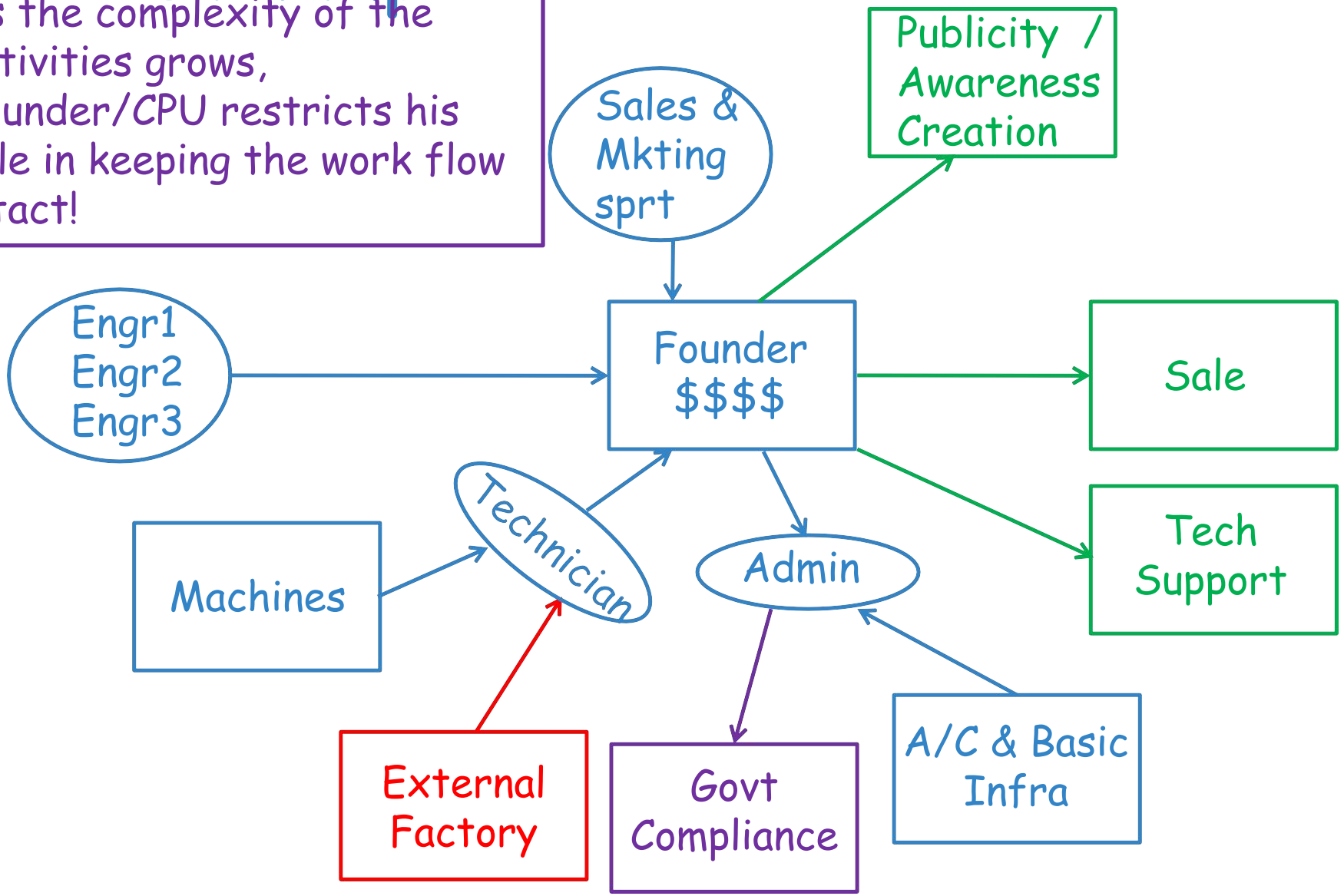


Basic Structure of a Startup

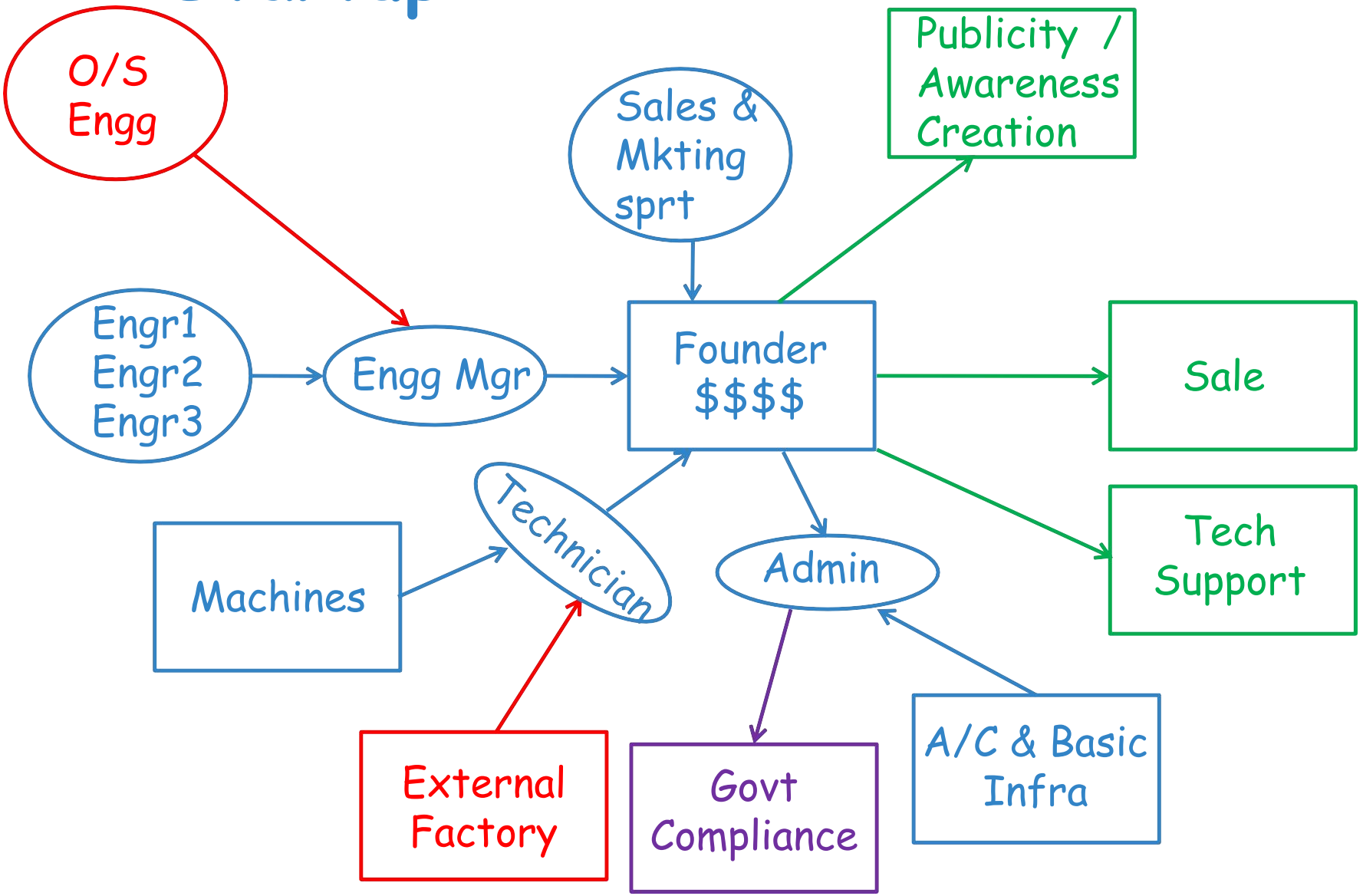


Basic Structure of a Startup

As the complexity of the activities grows, Founder/CPU restricts his role in keeping the work flow intact!



Basic Structure of a Startup



Founder/CEO vsCPU

- As the organization grows, Founder delegates its work to team members. On the other hand, fixed resources are at the disposal of CPU since beginning. CPU has to ensure that it is able to meet the objective without any further need of external resources.
- Founder must have some free time to strategize / innovate. CPU must have free clock cycles for future scaling.
- As the complexity of task grows, Founder / CPU restricts its role in managing resources and information flow, and making sure that the end objective is met.

Org Structure vsuP Architecture

- Nature of core activity
- Size – Revenue, Manpower, Location
- Scale and future growth prospects
- Ecosystem

Org Structure vs uP Architecture

Org Structure & Resources	uP Architecture & Resources
Nature of core activity	Type of computation required (End Application)
Size – Revenue, Manpower, Geographical Locations	Complexity of processing and computation
Scale and future growth prospects	Supporting future development / versions
Ecosystem – External vendors	Availability of interfaces to interact with other modules in the system
Competitive (external) environment	??

Setting Priorities of a Boss

A. Phone calls, door bells

B. Government compliance (Return filing & reporting)

C. Sales inquiry from a potential customer

D. Inquiry from a team member

E. Collaboration inquiry from a potential partner

F. Blind inquiries (mail/phone) from potential vendors

G. Clarification mail from a vendor executing your job

H. Tech support to the existing customers

I. Notices from various Govt departments

J. Well being of team members (Medical emergency)

K. Yaar ki shaadi

Setting Priorities of a Boss

A. Phone calls, door bells

B. Government compliance (Return filing & reporting)

C. Sales inquiry from a potential customer

D. Inquiry from a team member

E. Collaboration inquiry from a potential partner

F. Blind inquiries (mail/phone) from potential vendors

G. Clarification mail from a vendor executing your job

H. Tech support to the existing customers

I. Notices from various Govt departments

J. Well being of team members (Medical emergency)

K. Yaar ki shaadi

Quiz: Prioritize these.

Interrupting/Informing the CPU

- Set the priorities
- How would each interrupt be handled. Possibilities -
  - Leave everything immediately and serve the request. Once the request is served, come back and complete the unfinished task.
  - Serve the request only after completing its ongoing task. Once the interrupt is served, come back to the ongoing flow.
  - In case of multiple simultaneous requests, prioritize them.
  - .
  - .

Welcome to the world of Microprocessors

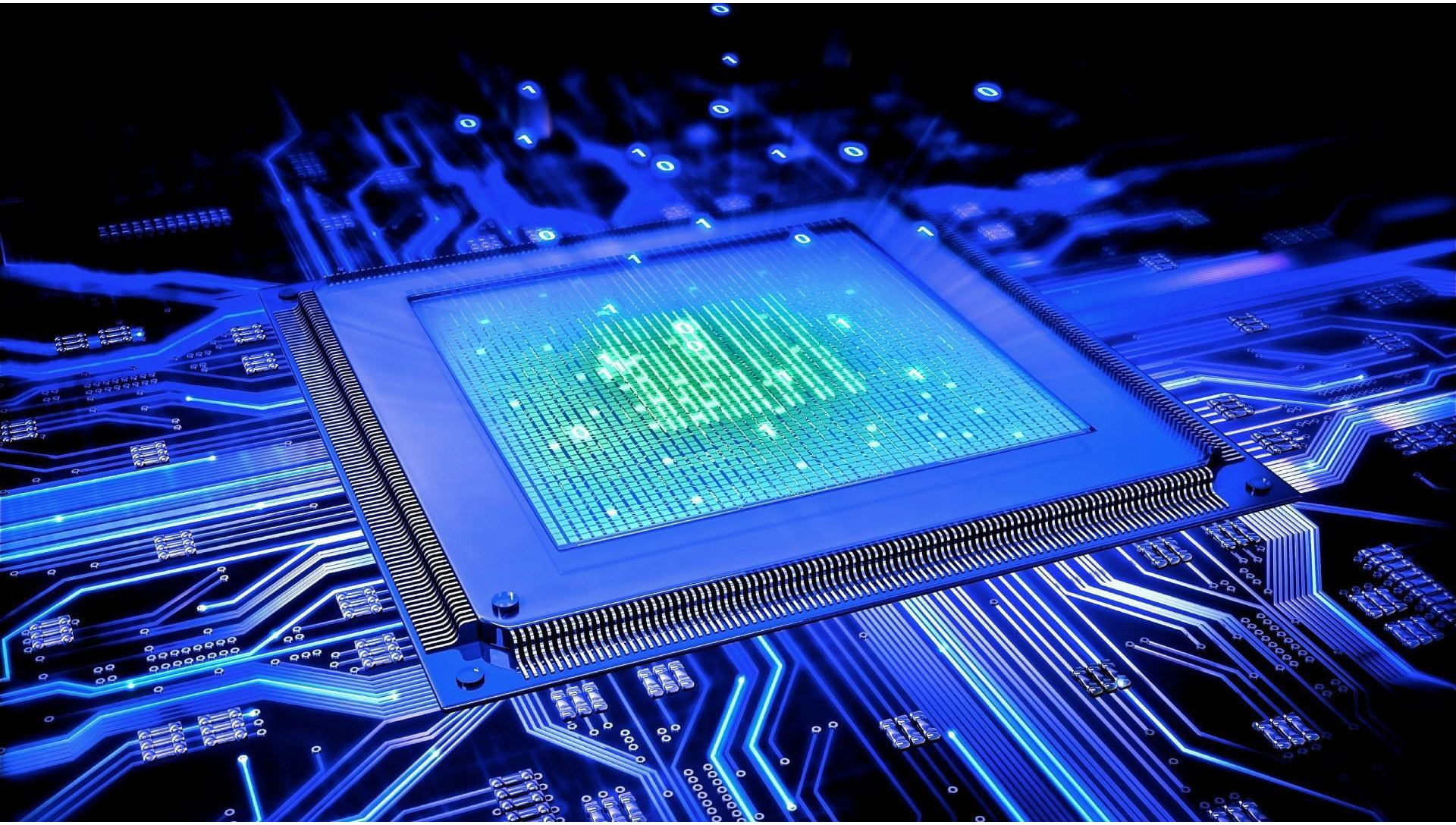


Image source - http://qige87.com/intel-wallpaper.html

CPU- CEO Analogy

CPU- CEO Analogy

- CPU ≡ CEO of an org
  - Both are must and have limited time!

CPU- CEO Analogy

- CPU ≡ CEO of an org
  - Both are must and have limited time!
- CPU's h/w resources ≡ CEO's team

CPU- CEO Analogy

- CPU ≡ CEO of an org
  - Both are must and have limited time!
- CPU's h/w resources ≡ CEO's team
- CPU's clk cycles ≡ CEO's time

CPU- CEO Analogy

- CPU ≡ CEO of an org
  - Both are must and have limited time!
- CPU's h/w resources ≡ CEO's team
- CPU's clk cycles ≡ CEO's time
- Clk cycles of h/w blks ≡ Team members' time

CPU- CEO Analogy

- CPU ≡ CEO of an org
  - Both are must and have limited time!
- CPU's h/w resources ≡ CEO's team
- CPU's clk cycles ≡ CEO's time
- Clk cycles of h/w blks ≡ Team members' time
- Idle CPU clock cycles MUST be avoided for power optimization (So is true with CEO's time)

CPU- CEO Analogy

- CPU ≡ CEO of an org
  - Both are must and have limited time!
- CPU's h/w resources ≡ CEO's team
- CPU's clk cycles ≡ CEO's time
- Clk cycles of h/w blks ≡ Team members' time
- Idle CPU clock cycles MUST be avoided for power optimization (So is true with CEO's time)
- Scaling CPU (or h/w blk) clock freq may help (Org may benefit by increasing/decreasing CEO's or others working hrs)

CPU- CEO Analogy

- CPU ≡ CEO of an org
  - Both are must and have limited time!
- CPU's h/w resources ≡ CEO's team
- CPU's clk cycles ≡ CEO's time
- Clk cycles of h/w blks ≡ Team members' time
- Idle CPU clock cycles MUST be avoided for power optimization (So is true with CEO's time)
- Scaling CPU (or h/w blk) clock freq may help (Org may benefit by increasing/decreasing CEO's or others working hrs)
- Cut power & clk of the unutilized h/w blk (≡?)

CPU- CEO Analogy

- CPU ≡ CEO of an org
  - Both are must and have limited time!
- CPU's h/w resources ≡ CEO's team
- CPU's clk cycles ≡ CEO's time
- Clk cycles of h/w blks ≡ Team members' time
- Idle CPU clock cycles MUST be avoided for power optimization (So is true with CEO's time)
- Scaling CPU (or h/w blk) clock freq may help (Org may benefit by increasing/decreasing CEO's or others working hrs)
- Cut power & clk of the unutilized h/w blk (≡?)
- Multi core system (multiple founder startup)

What is the Internet of Things

Image from
http://www.cchc.cl/informacion-a-la-comunidad/industria-de-la-construccion/personaje/

Sensors

ubiquitous crunch

Measure values

Send raw data

Low power

Local Processing and Local Storage

Get data from sensors

Process

Send some data to

Edge/Fog Computing

Network and Internet

IoT Gateway

Gathers data from sensors

Protocols

- CoAP
- MQTT
- HTTP
- XMPP

Cloud Processing and Storage

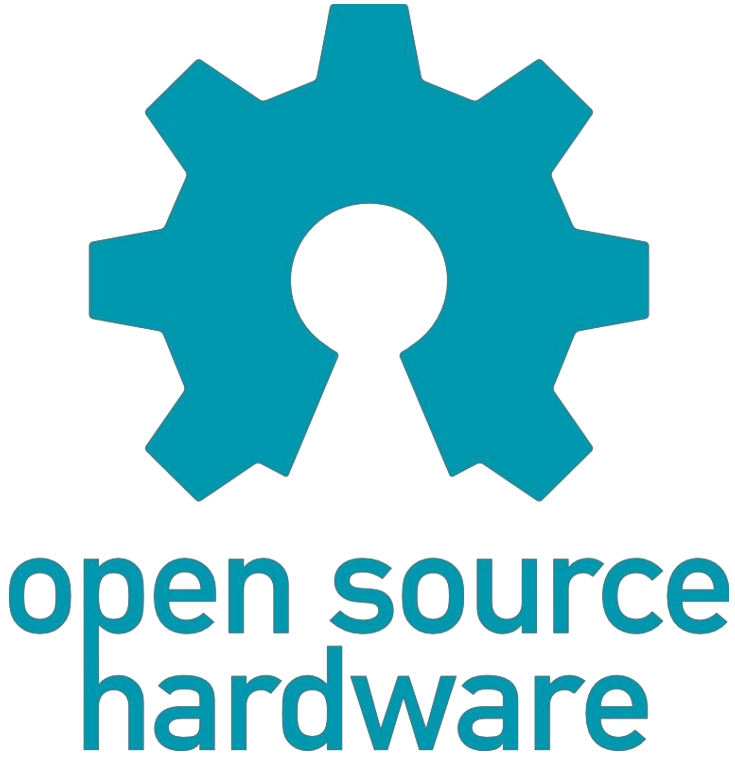
ubiquitous crunch

Aggregate Data

Storage

Inferences

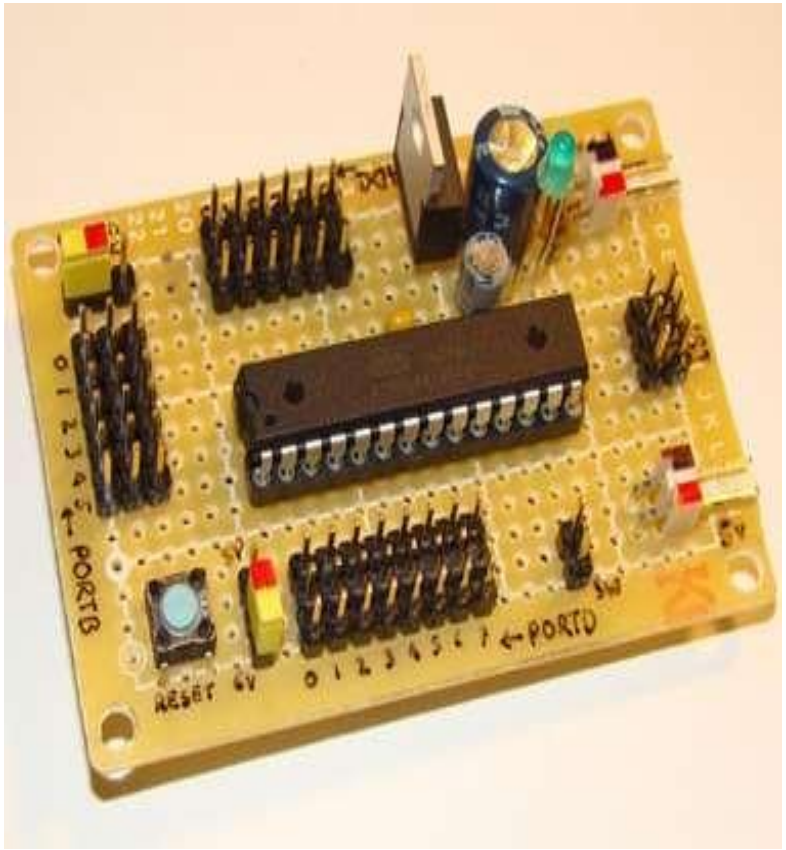
How did it start



Microcontroller

Small programmable device

Easy connectable



Arduino

Small programmable device

Easy connectable

Is open source

Has a simple to use software

Arduino Ethernet

Small programmable device

Easy connectable

Is open source

Has a simple to use software

Only around 4 simultaneous networking connections

Raspberry Pi

Computer

Runs Linux
More software oriented

programming Full

Networking System

Raspberry Pi and Arduino

HARDWARE

SOFTWARE AND NETWORKING SYSTEM

Hardware


Arduino
Raspberry
Intel® Galileo
Intel® Edison
Beaglebone Black UDOO
Parallella

Good for sensors

Arduino

$25

ATmega328

ChipKIT

$30

PIC

LaunchPad

$4

MSP430

Good for some sensors and processing

STM32

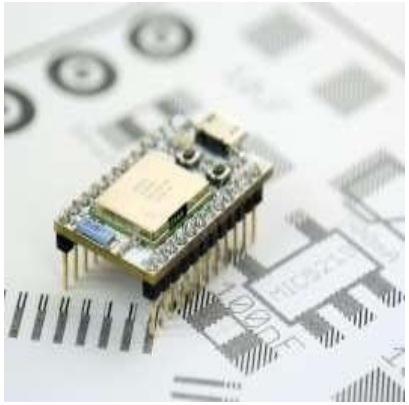
$30

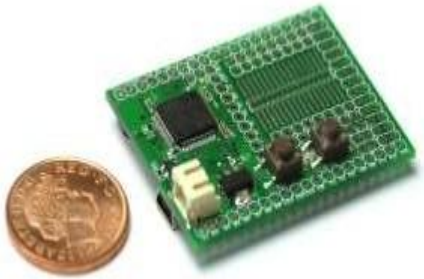
ARM Cortex
M0, M3, M4

Particle

$35

ARM
WiFi
Internet





Espruino

$30
ARM
Javascript

Good for processing and network

Raspberry Pi

$35

900 MHz ARM, GPU
1 GB RAM

Intel® Galileo

$50

400 MHz Quark x86
256 MB RAM

Intel® Edison

$70
1 GHz Dual Core Atom x86 1 GB RAM
WiFi
BLE
4 GB Flash

Good for processing and network

Beaglebone Black

$45

1 GHz ARM, GPU
512 MB RAM
4 GB Flash

UDOO Neo

$50

i.MX 6 Solo ARM, GPU
ARM M4
512 MB or 1 GB RAM

Parallella

$99

1 GHz Dual Core Zynq ARM
16 or 64 Epiphany CPUs