

# Cooperative Wireless Communication Networks

Ganesh

Trying to be Activist, Independent Researcher & Hacker

*31gane@gmail.com*

April 20, 2018

# Overview

## Fundas ... !

Why ?

Lots of Reasons !

What ?

Mesh Fount

Radio Mesh - come again !

Convergence & Symbiosis

How ?

Community Fount

## Hardware

How we Feel ?

Spectrum

Work ! - Real Physical Work

Radiation

Guiding

Routers

## Software

How we Feel ?

Firmware & OS

Protocol Stacks

Services & Apps

## Emergence & Cognition

# License

This document is licensed under Creative Commons NC ND 4.0.  
This document represents mostly my thoughts, research,  
experiences and references to other creative works.



Read the CC NC ND 4.0 License Deed [here](#)  
Read the CC NC ND 4.0 Legal Code [here](#)

WHY ?



Change

Interest

Frustration

*Towards :*

adaptive

emergence

participation

self regulation

distributed - decentralization

commons based peer production





Common guys !, what are the possibilities.... ?

- ▶ Building a RMN(Radio Mesh N/W) Locally is itself Fun, Exhilarating
- ▶ Great Hobby - similar to Amateur Radio, Astronomy...
- ▶ Converging experience of Hardware & Software Equally
- ▶ Really get to know mechanism of Network - Stck Layers (OSI or EWI)
- ▶ Hack the Physical Layer
- ▶ Create & test new protocols

# Learning & Sharing



What is a Mesh?



What is a B.A.T.M.A.N?



What is a OLSR?



Where is the J.O.K.E.R?



AwesooooomEEEE !

Am i profiled?



Asta La GNU !



What is a Wave really?



Chat without Track!



EM wave is like "beebabeebeee"!



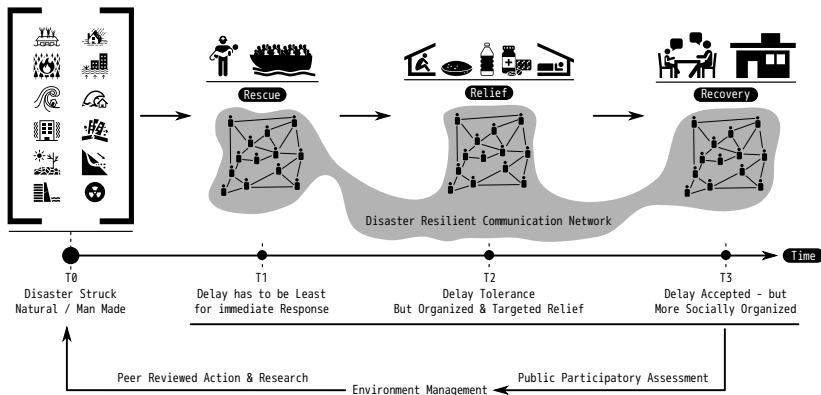
Commons Produced?  
AaawesssomEE !



Yeah Dude !

# Times of Emergency - Disaster & Calamity

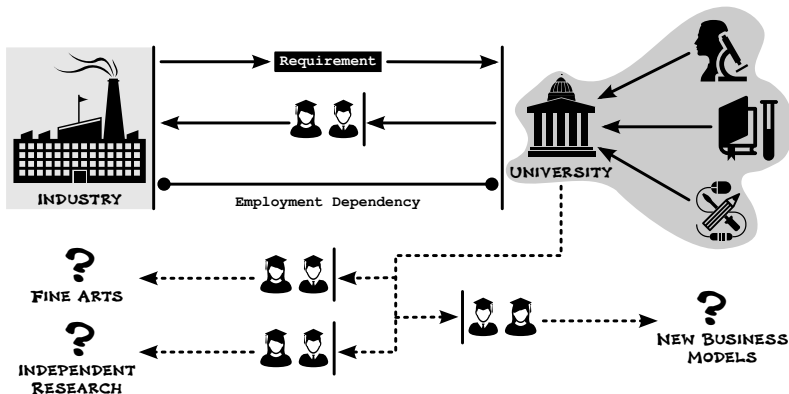
Meshed/Distributed - (Un)Licensed Network play a Vital Role.



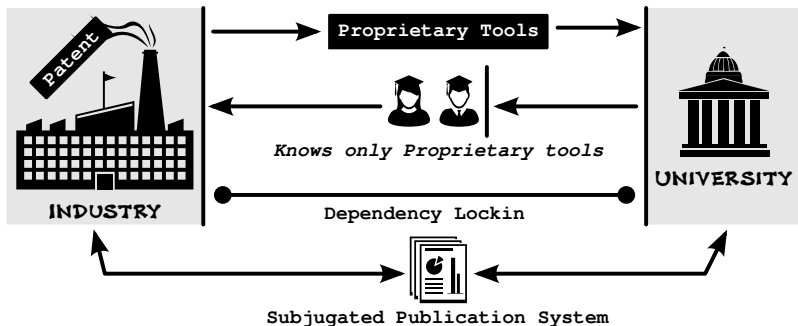
Ex: **Emergent** Mesh Networks(Amateur Radio, Community Radio)

# Education & Business Models

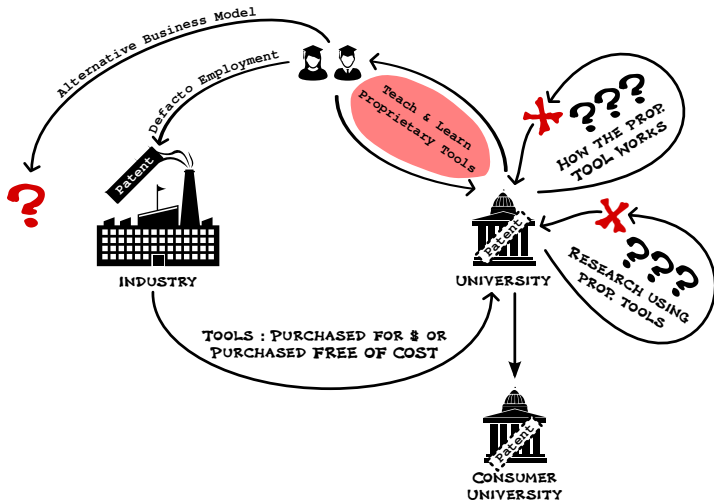
Paradigm change in Education & Business Models are necessary



Really ? Common..... be Honest !



Is this even possible ???



# What about Internet ?

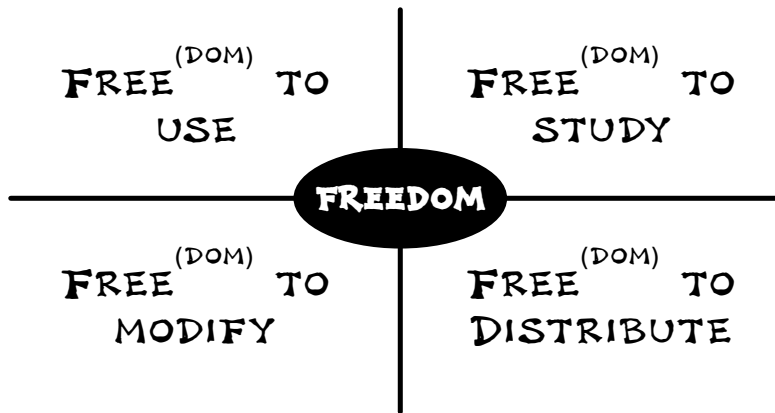


Sidewalk Bubblegum ©1998 Clay Butler

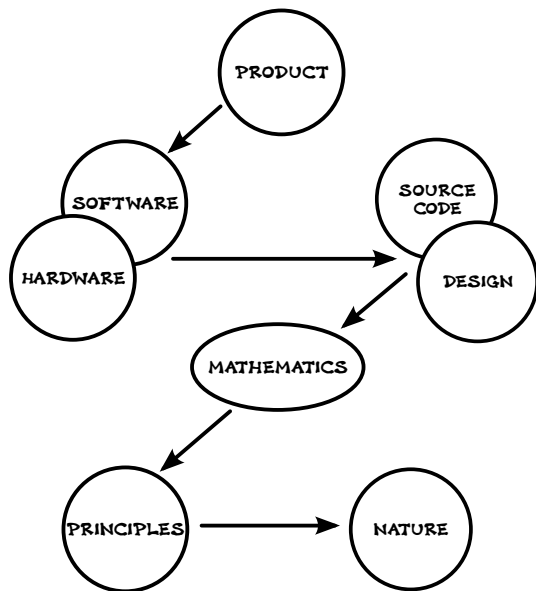
**WHAT ?**



# Four Necessary Freedoms



# Affordability - Availability - Accessibility



# Radio Mesh Network Infrastructure

***Mesh Community*** = Commons Peer Production + Collaboration

***Mesh Medium*** = (Un)Licensed Spectrum + Shared Channel

***Mesh Node*** = Cognitive Radio(TX/RX) + Feeder + Antenna

***Mesh Service*** = Framing + Routing + Encryption

***Mesh Application*** = Distribution Framework + Human Touch

# Radio Spectrum

**Radio Spectrum** = Collection of Radio Frequency

**Spectrum Usage** = Exploration + Communication = E + C

**E** = Radio Astronomy + Spectroscopy + BioMedical

**C** = Broadcasting + Telecom + Community Radio + Amateur License

**Radio Resource** = Bandwidth + Channel + Capacity + Coverage

Radio Regulations for **Ethical** Usage

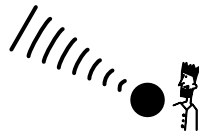
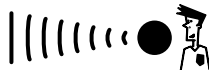
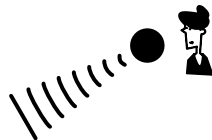
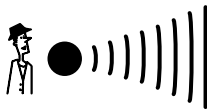
Beware of Radio **Spectrum Adjudication** based on Local Law & Regulation

# Radio Mesh Network Connections



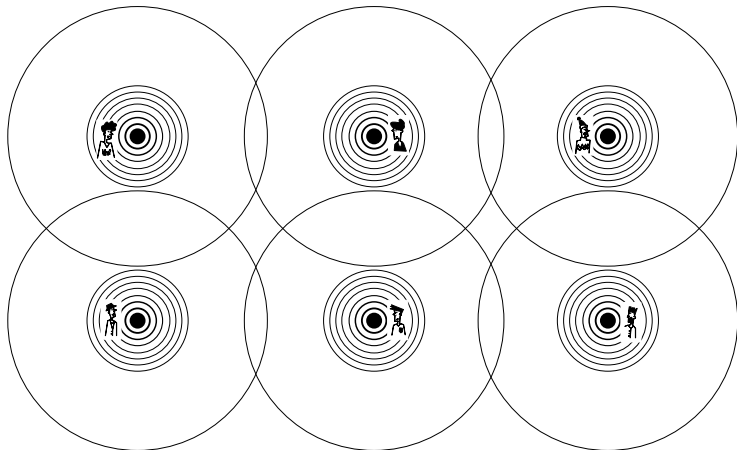
Point to Point

# Radio Mesh Network Connections...



Point to Multi-Point

# Radio Mesh Network Connections...



Multi-Point to Multi-Point

# Radio Mesh Networking

Radio Mesh Network (RMN)

=

Radio Backbone links (*Adhoc - Mesh Aware*)

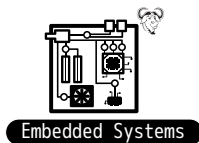
+

Radio Access-point links (*Infrastrcutre - Mesh Agnostic*)



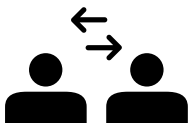
# Awesome ! Convergence

DREW = Desktop + Radio + Embedded + Web

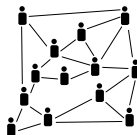


# Awesome ! Convergence ...

Distributed Peer to Peer + Collaboration + Cryptography



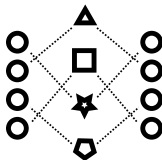
Peer to Peer Systems



Distri-Mesh Systems



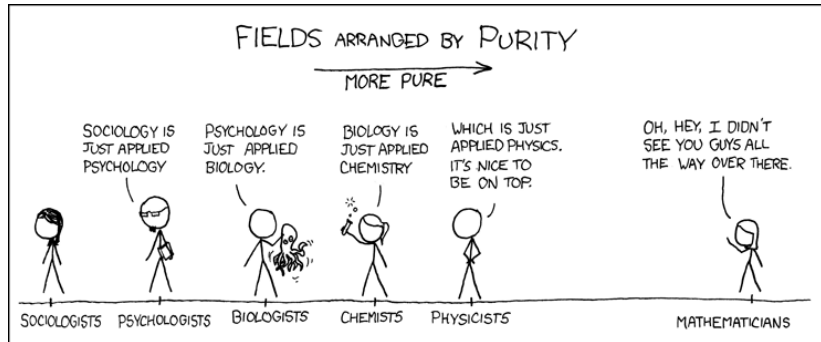
Collaborative Systems



Crypto Systems

**HOW ?**

# Community in Diversity :p



## Common Interest Group



### Hardware Wing

#### Electromagnetics

Antennas  
Transmission Lines  
Connectors  
Radio Planning  
Link Budget  
Manual Survey  
GIS Survey

#### Electronics

Radio TX/RX  
Microcontroller  
Schematics  
PCB  
DataSheet

Free Hardware



### Firmware Wing

Bootloader  
Uboot  
Build System  
Buildroot  
BitBake  
Operating System  
GNU/Linux  
Device Driver  
Kernel Module  
Mesh Network Services

Free Software



### Applications Wing

Education  
Transportation  
Environmental  
Citizen Research  
Citizen Science  
Commons Journalism  
Community Radio  
GeoTransformation  
Collective Weather  
Disaster resilience

Free Software



### Propagation Wing

Workshops  
Mesh-athon  
Map-athon  
Sharing Parties  
Field Day  
Out Reaching Societies  
Sports  
Local Entrepreneurship

Free Culture



## Form a Critical Thinking Group



DIY Routers or Hackable Routers

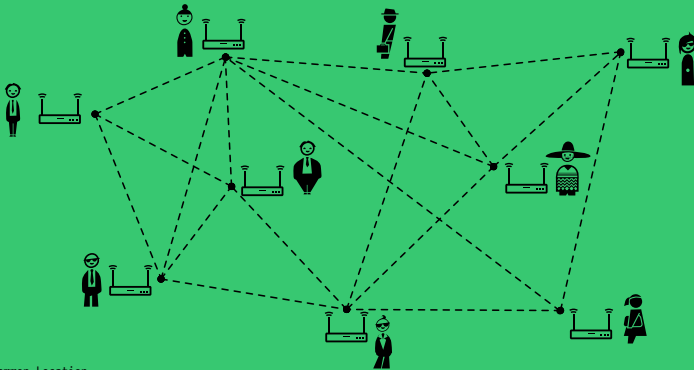


Flash the custom Firmware and Mesh system Module



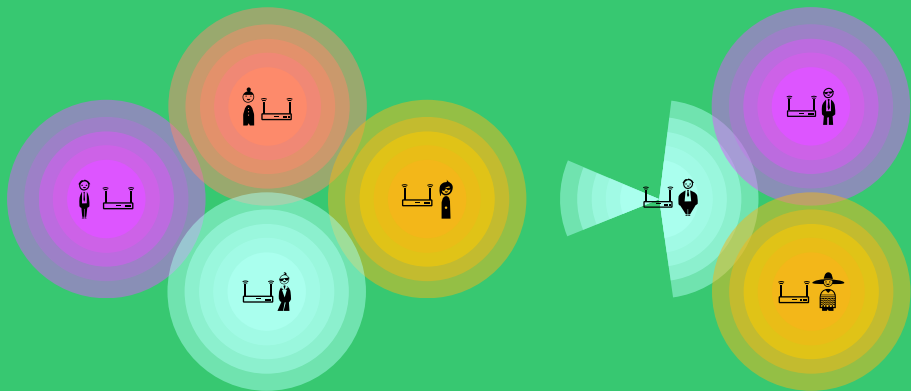
Share the Procedure





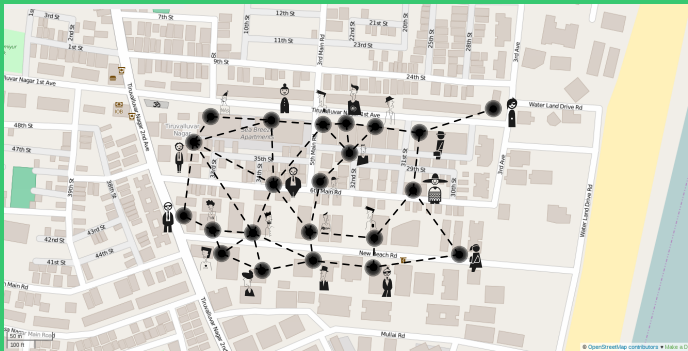
Select a common Location  
Start connecting with each other  
Test by increasing the density  
Test by moving around

Understand the Networks Scalability, Efficiency, Effective Range, Quality by measuring Network Parameters



Choose a Local Area Geography - with optimum distances overlapping each routers effective range  
Mount the Routers, Supply power (Mains powered or Renewable Powered)  
Try to Connect with another peer in adjacent geographical area using Line of Sight Connection



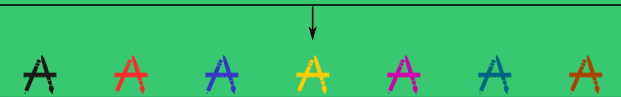


Choose a Local Area Geography - Map their locations in Community map application  
Fire up the Antennas, Radios, Routers, Form the topology  
Try to Establish the Mesh Network

Discover Requirments  
of Local People



Develop applications  
to meet those  
requirements



Organize Public  
Meetings



Make them Participate  
Make them Use the Network  
in Interesting Ways !!!



Symbiotically relate Local Business Ecosystem & Education with the Mesh Network Infrastructure

# HARDWARE

When it comes to Physics, Ground Work & Hardware

— — — — —

i have seen people GO LIKE THIS !!!



Me ??????

— — — — —

YEAH !!! Me Tooooooooooooooooo !

EM Spectrum  $\equiv$  Water, Land, Atmosphere

- - - - -

- ▶ A channel (frequency/band) becomes a resource
- ▶ Resource mgmt. between Stake Holders(SH)
- ▶ SH = Commons + Fraternities + Establishments
- ▶ Resource mgmt. through Mutual sharing strategy
- ▶ Resource mgmt. through "Regulatory" agencies

# Which Spectrum for RMN ?

Licensed  $\equiv$  (Amateur, Military, Telecom, Broadcast) Bands

Unlicensed  $\equiv$  (ISM, Wifi) Bands

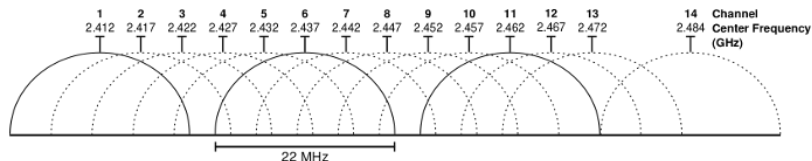
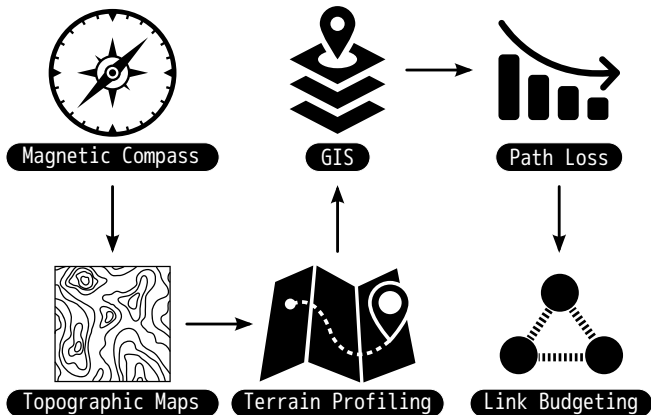


Figure: 2.4GHz Wifi Band



# Radio Planning, Budgeting

≡ Survey, Geography, Material, Resources



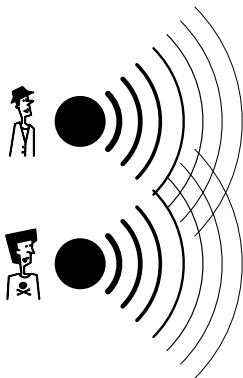
# Antenna & Radiation

≡ Eyes, Ears, 7/11 Mouth

1. Resonance, Frequency, Phase, Amplitude
2. Propagation, Reflection, Refraction, Diffraction, Scattering
3. Constructive & Destructive Interference
4. Standing Wave, Reflections & Matching
5. Antenna Gain, Directivity, EIRP
6. Bandwidth - Narrow Band & Broad Band
7. Multipath Channeling = SISO, SIMO, MISO, MIMO
8. Free Space Path Loss

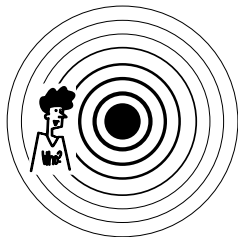
# Phase, Frequency, Amplitude

What happens during Interference - Construction ? Destruction ?



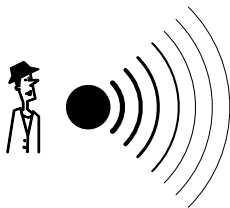
Ever heard of Double Slit Experiment ??

# Omni-Directional Antenna



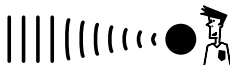
List

# Sectoral Antenna



List

# Highly Directional Antenna



List

How we Designed an Yagi-Uda Antenna ?

# Scavenging Resources

DIY = Scavenge + Upcycle + Repurpose + Hacking



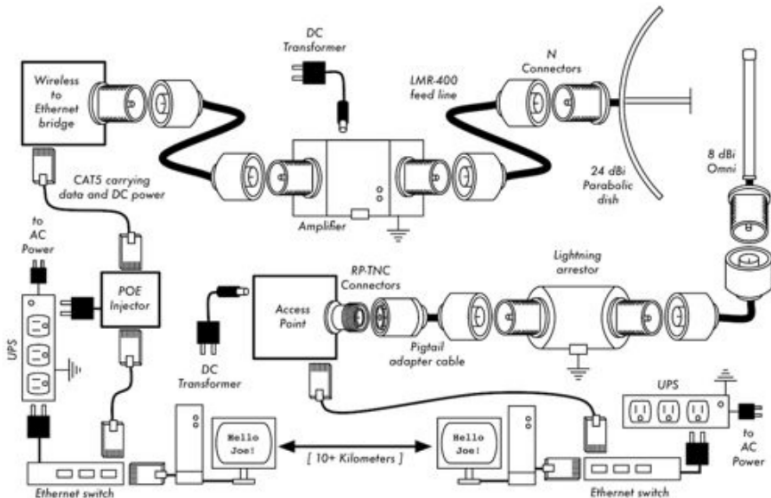
## ≡ Nerves

1. Wave Guiding, Skin Effect
2. Standing Wave, Reflections & Matching
3. Cable Loss, Filter effect
4. Connectors, Insertion Loss



# RF Feeds & Connectors...

Could U see why i called them **Nervesssss** ?



≡ Mushy Mushy Organs

1. Stable RF Oscillator
2. RF Controller
3. Frequency, Amplitude, Phase Control
4. EM Regulation policy
5. Matching, Mixing, Conversion
6. Modulation, Demodulation, Encoding, Decoding
7. Filtering, FPGA, DSP

# Free Projects :)

Atlast !



# Past, Present, Future

## 1. Past

1.1 DX, APRS, WSPR

1.2 Software Controlled Radio

## 2. Present

2.1 HSMM, Community Wireless Networks

2.2 Software Defined Radio, FPRF modules

2.3 Cognitive Radio, Fractal Antennas

2.4 Spectrum Activism, Emergency Resilience

2.5 Citizen Research, Science, Journalism

## 3. Future

3.1 Configurable & Origami based Antennas

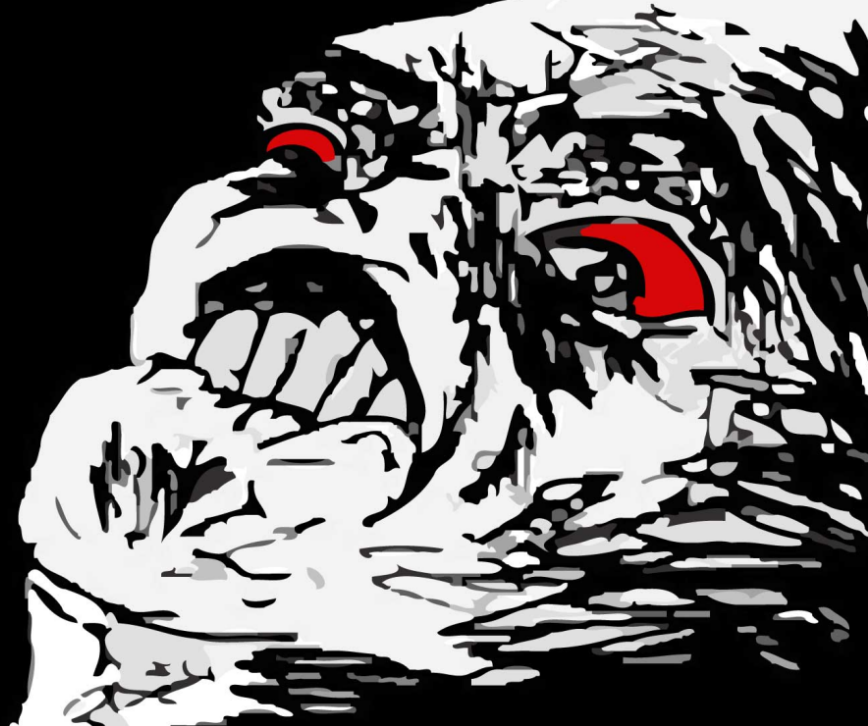
3.2 Affordable Meta-material Antennas

3.3 Grass Roots Telecommunication

3.4 Self Regulating, Self Healing Networks

# SOFTWARE

When it comes to Software - Myself - GO LIKE THIS !!!



# Router Firmware

```
#include <gnu/linux>

int void proprietary_hardware() {
char*[] OS = { "OpenWRT", "DDWRT", "Byzantium", "MeshPotato", "Custom_Build" };

switch(OS) {
case("OpenWRT") { Check_Compatibility(); flash_os(OS); }
case("DDWRT") { Check_Compatibility(); flash_os(OS); }
case("Byzantium") { Check_Compatibility(); flash_os(OS); }
case("MeshPotato") { Check_Compatibility(); flash_os(OS); }
case("Custom_Build") { Check_Compatibility(); flash_os(OS); }
}

if(router == BRICKED) {
printf("calm down");
try(reset_button());
if(router == STILL_BRICKED) {
try(serial_flashing_uboot_mode());
}
}

configure(wifi);
configure(access_point, adhoc);
configure(batman,install);
configure(configure_DHCP);

if(web_interface == NULL) {
try(ssh_root_access);
reset(all_network_settings);
}
else {
router_state = BRICKED ;
}

return(0);
}
```



# Custom Build is Awesome...

- ▶ That's what learning is about
- ▶ Learn GNU/Linux for Embedded targets
- ▶ Writing Device Drivers + Kernel modules

In RMN we share a common medium (channel)

- ▶ Routing becomes Vital
- ▶ Layer 3 Routing like OLSR
- ▶ Layer 2 Routing like B.A.T.M.A.N
- ▶ Plenty of room for new protocols & experimentation
- ▶ Peer Identification Mechanism
- ▶ PKI Cryptography @ Session & Application Layers
- ▶ Distributed Hash Table @ Session & Application Layers

# P2P + Distributed Applications

Services & Apps that fits P2P & Distributed, archs. are need of the day !

- ▶ Services that reduces information logistics
- ▶ Services that gaurantees Privacy
- ▶ Services that considers every node equal
- ▶ Services that require only knowledge as entry point with very minimal cost
- ▶ Apps. that Targets Local First - strategy
- ▶ Apps. that helps solve common social problems have great socio-economic impact
- ▶ Help shift from Central markets to Distributed & Collaborative markets
- ▶ Help Transform devices from Information Appliance to Computing Appliance



# EMERGENCE + COGNITION

# That's All Folks :)

Whaaaaaaat ??? Still want more !

- - - - -

Something is definitely wrong with you dude :P

# Credits

This Document Contains lot of icons, taken from collaborative internet web sites which offer the content under CC license.

Since every icons in each block diagram cannot be attributed seperately  
So i am providing the link where it can be from.

