Wireless Camera Node Network (WCNN)

FPR Presentation: April 15, 2015

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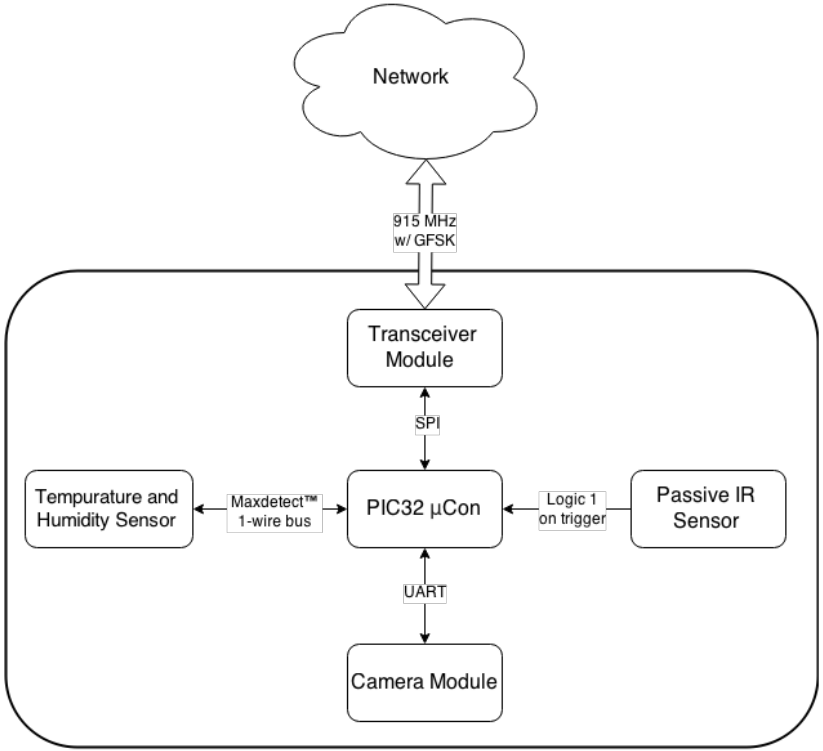
What is the Problem?

- Many wildlife species are becoming endangered.
- Animal behavior and habitation is often of interest.
- Determining how population sizes change over time is useful.
- There is no low-maintenance, way to surveil large areas for population analysis. Cameras with SD card are usually used.
- Existing solutions are expensive ($100s per camera).

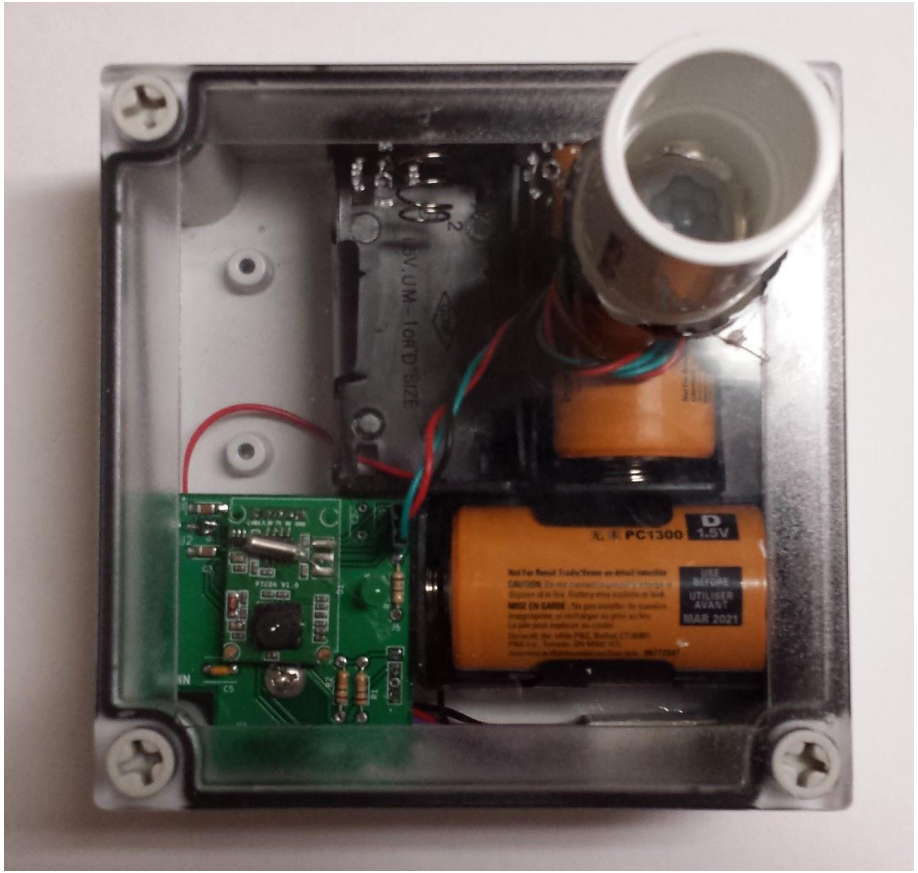
A wireless camera node network will provide a cheap, low-maintenance sensing solution for the analysis of animal populations.

Project Overview / Recap

Node Block Diagram

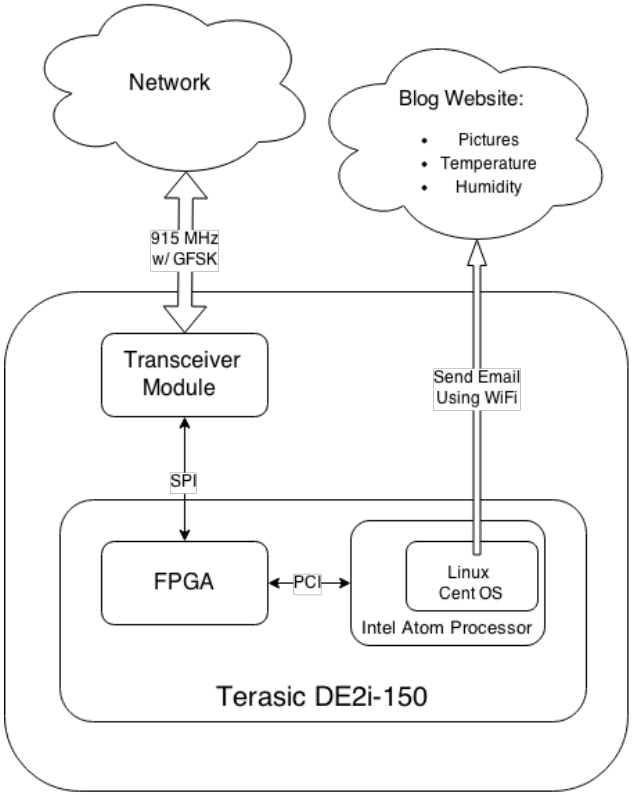


Finished Node

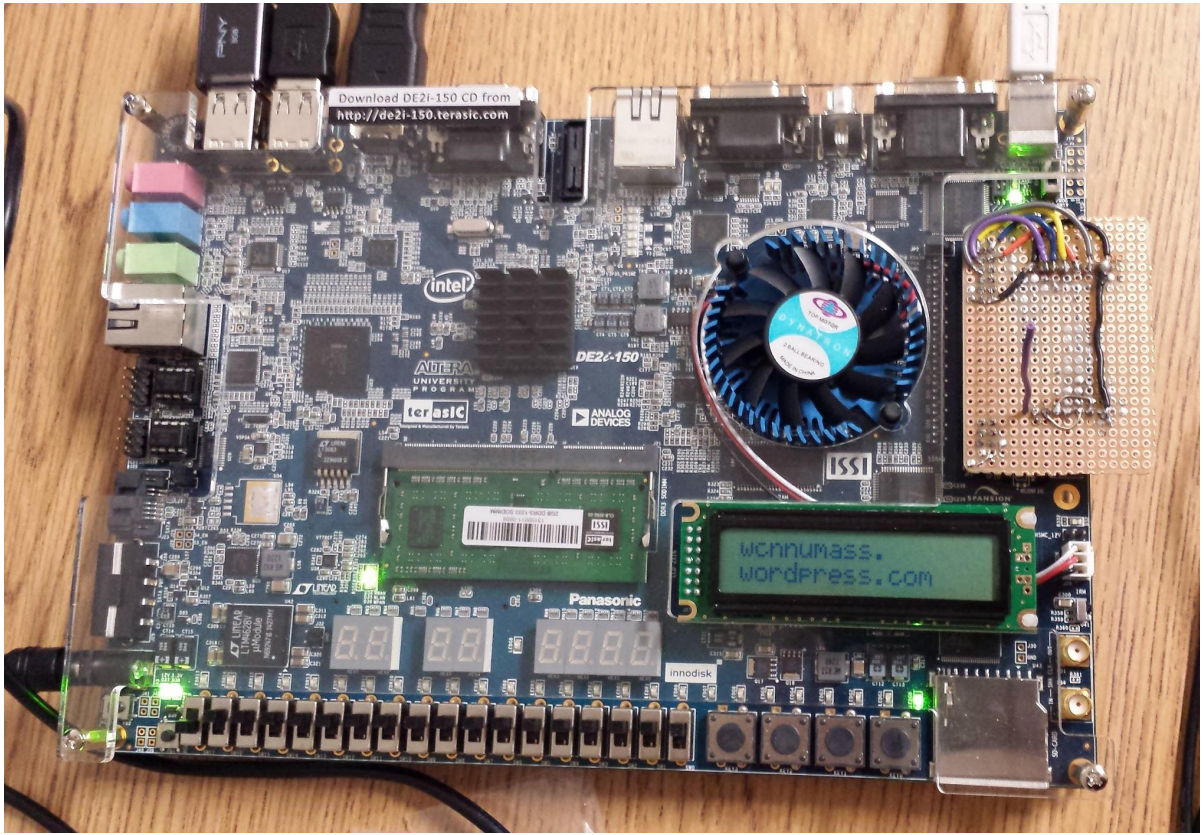


Project Overview / Recap

Server Block Diagram



The Server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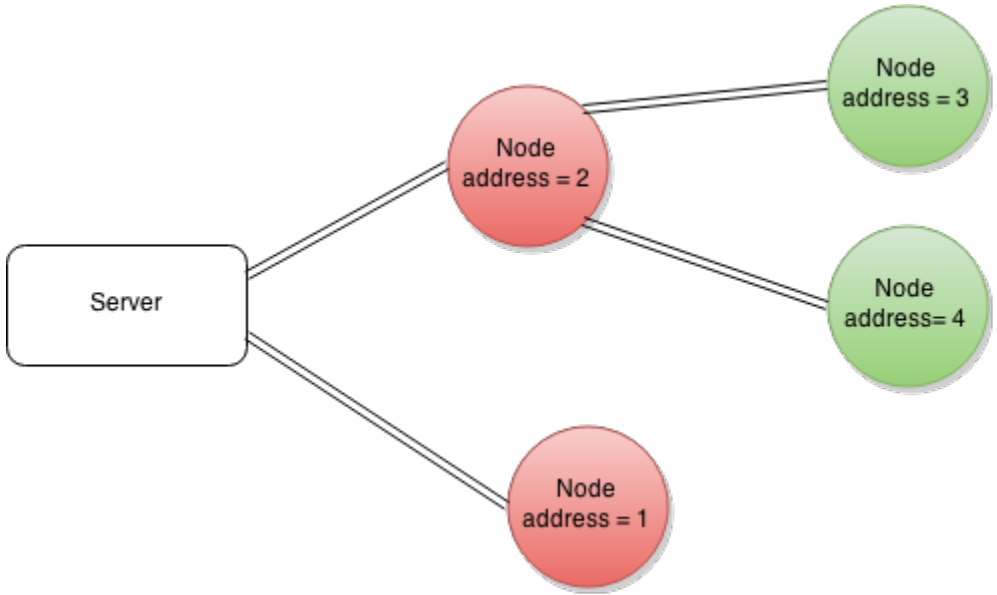
Recap of Sequential Network Protocol(1)

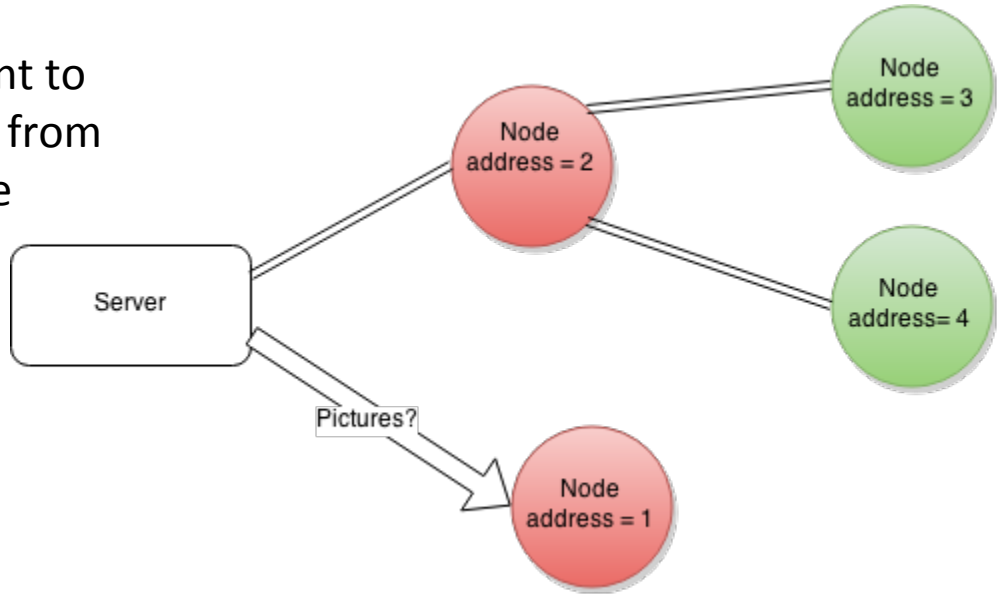
Nodes in green have stored pictures.

Nodes in red have no pictures

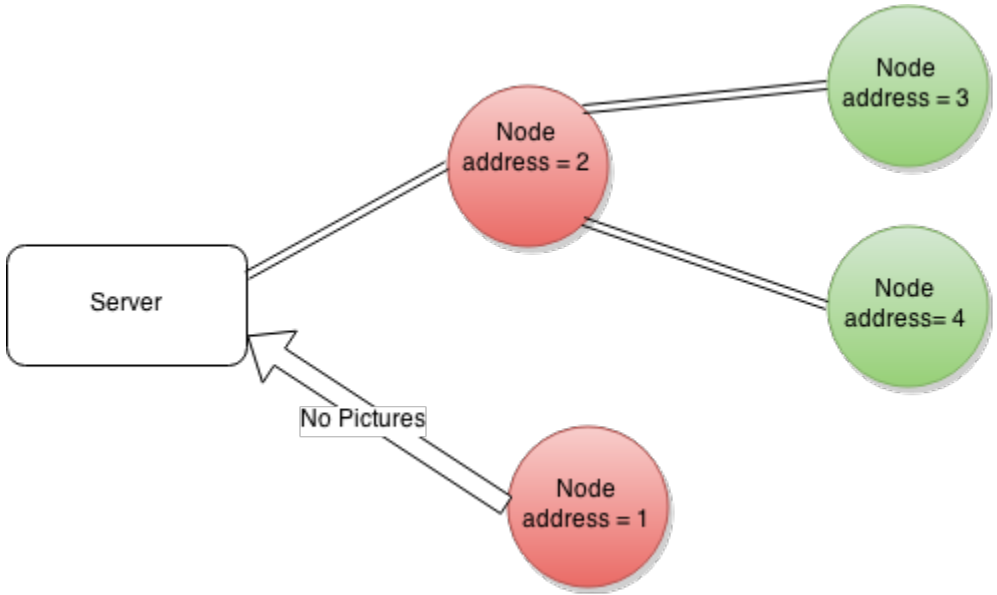


Finding and Pulling Pictures from the Network(2)

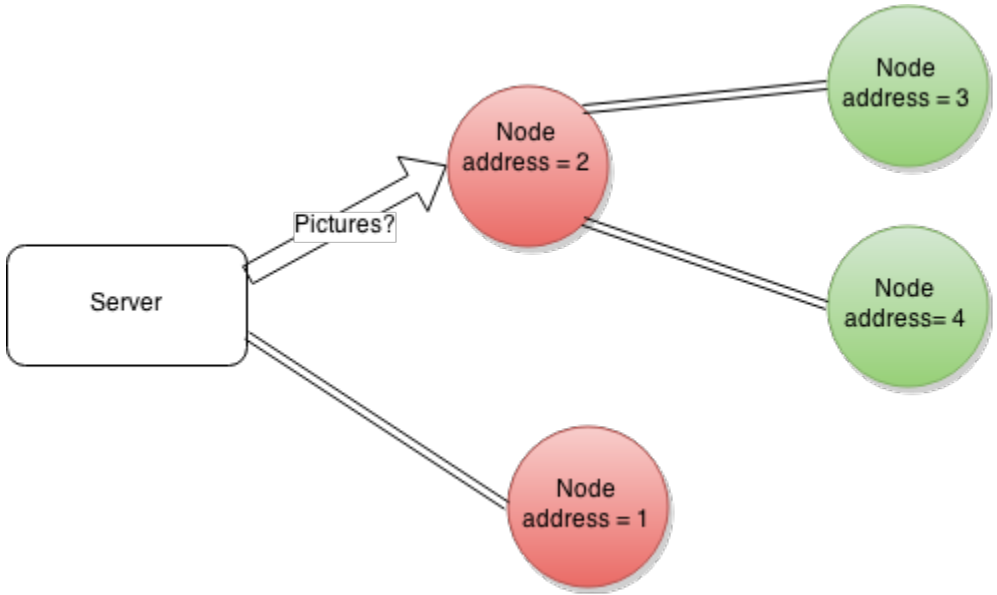
Suppose we want to get the pictures from the nodes to the website



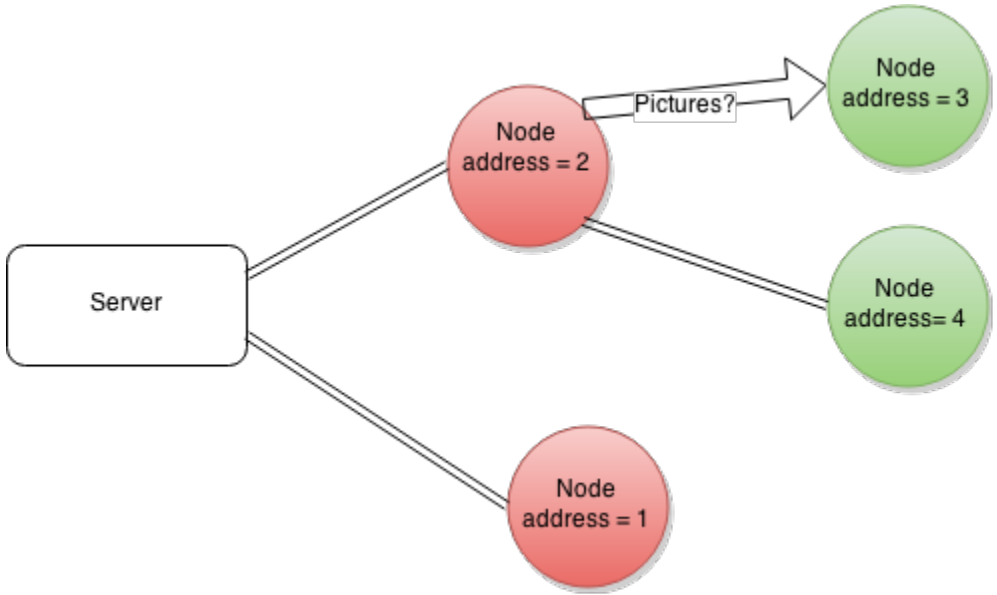
Finding and Pulling Pictures from the Network(3)



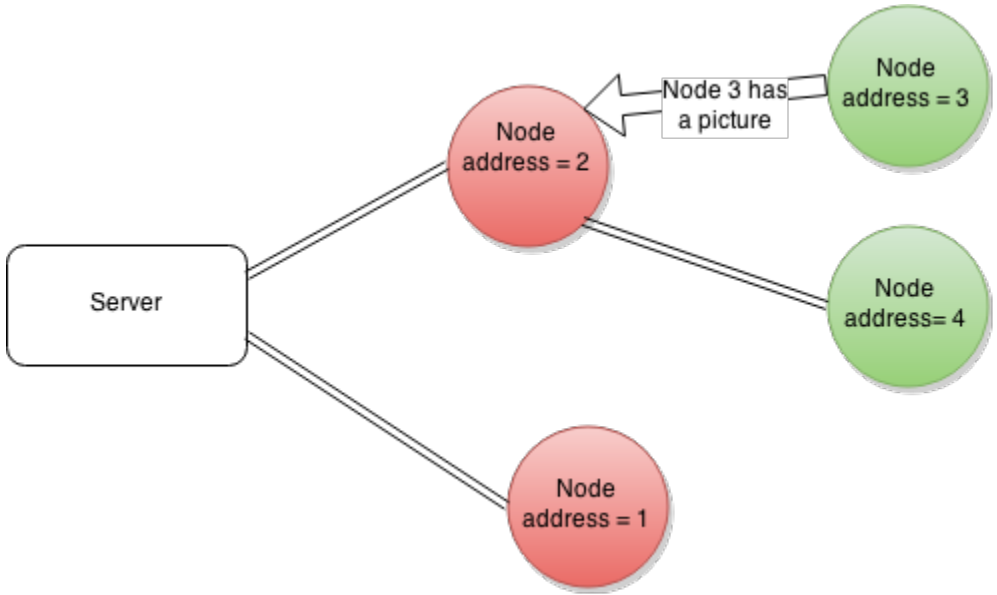
Finding and Pulling Pictures from the Network(4)



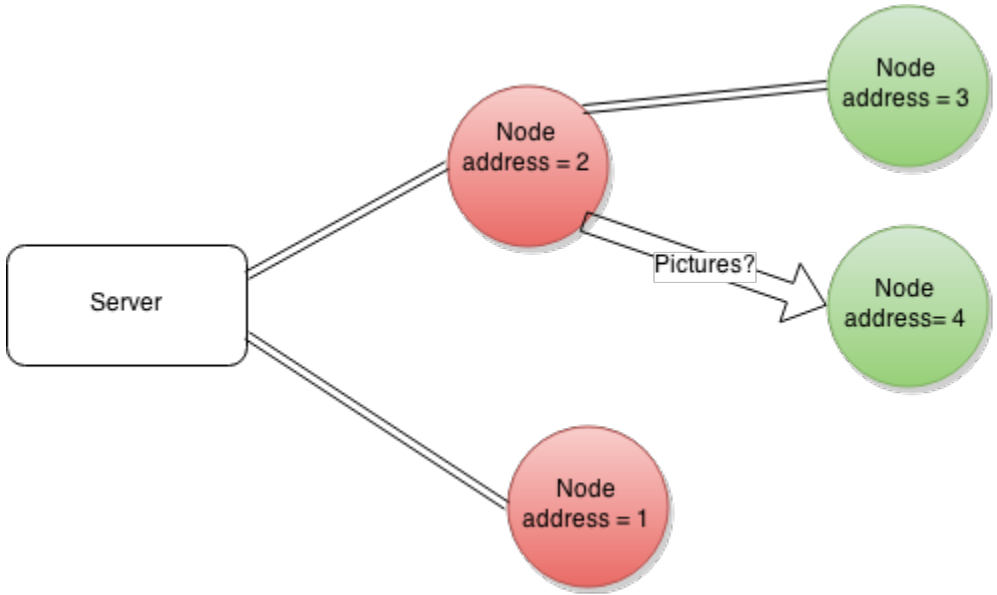
Finding and Pulling Pictures from the Network(5)



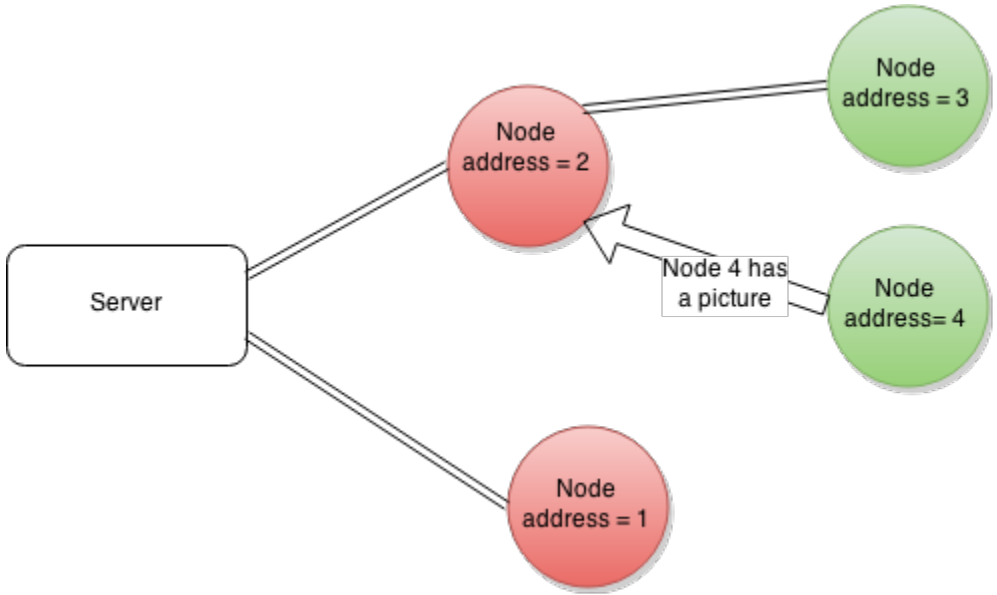
Finding and Pulling Pictures from the Network(6)



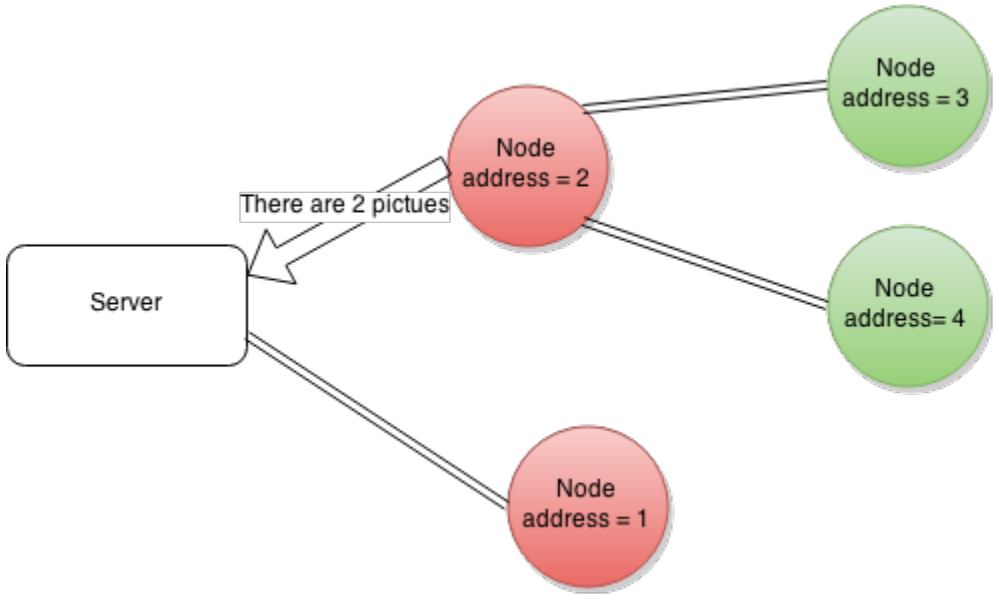
Finding and Pulling Pictures from the Network(8)



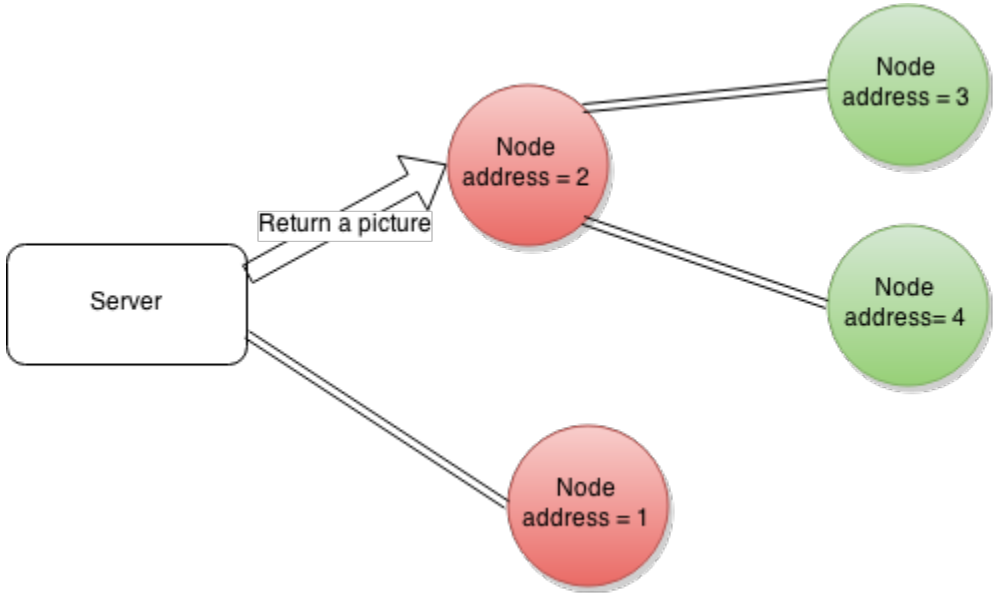
Finding and Pulling Pictures from the Network(9)



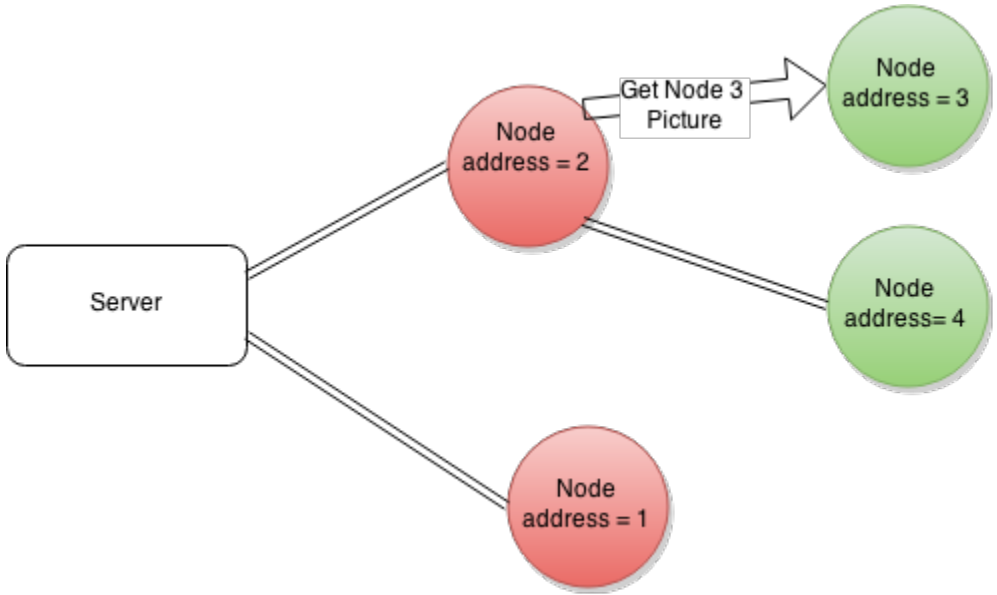
Finding and Pulling Pictures from the Network(10)



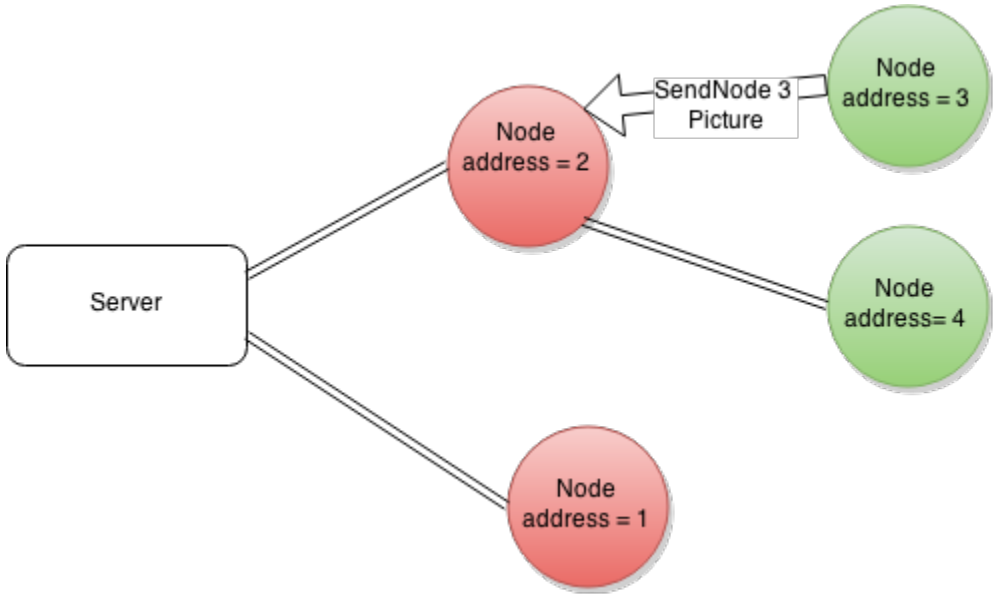
Finding and Pulling Pictures from the Network(11)



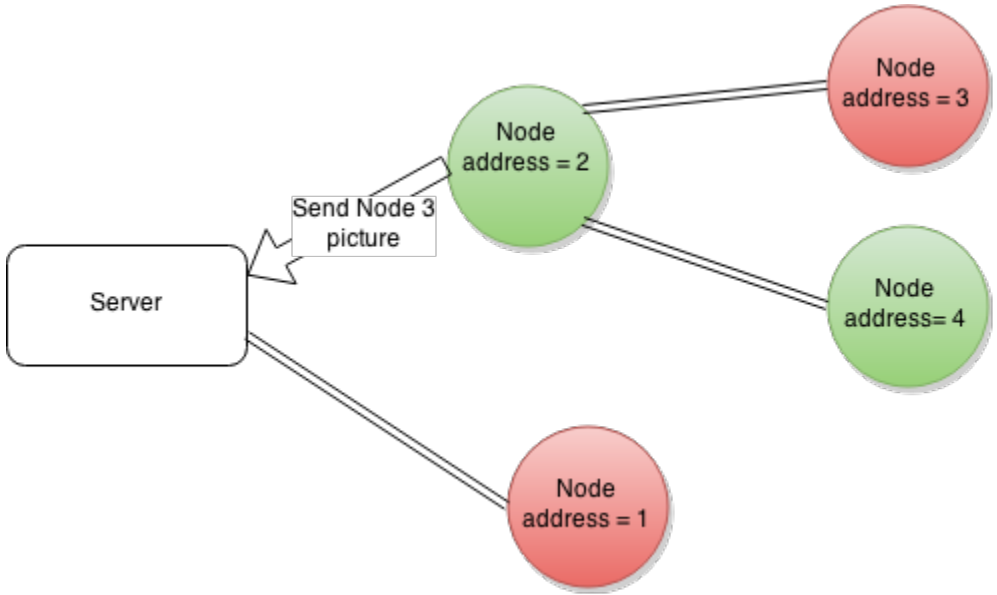
Finding and Pulling Pictures from the Network(12)



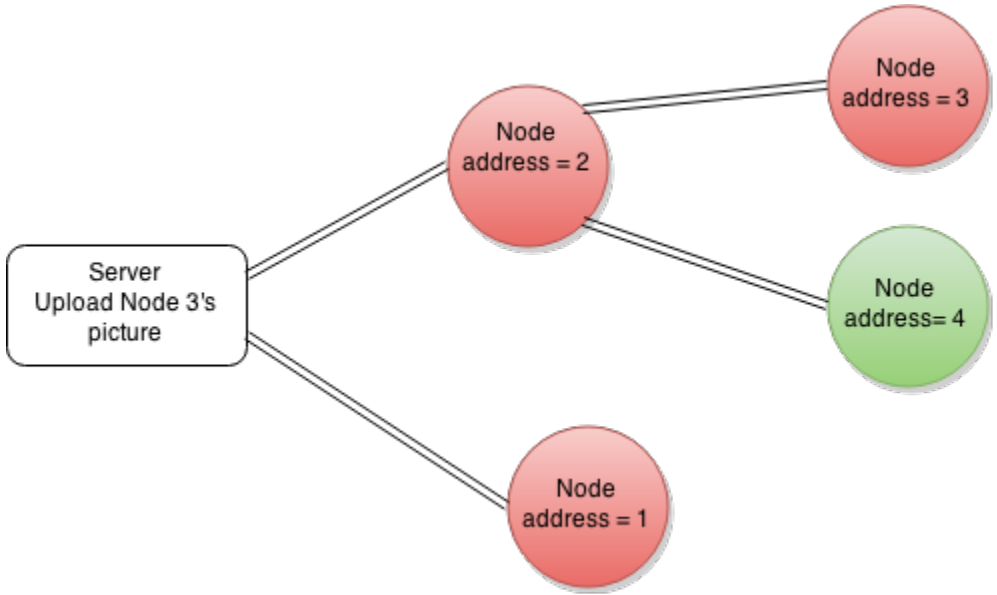
Finding and Pulling Pictures from the Network(13)



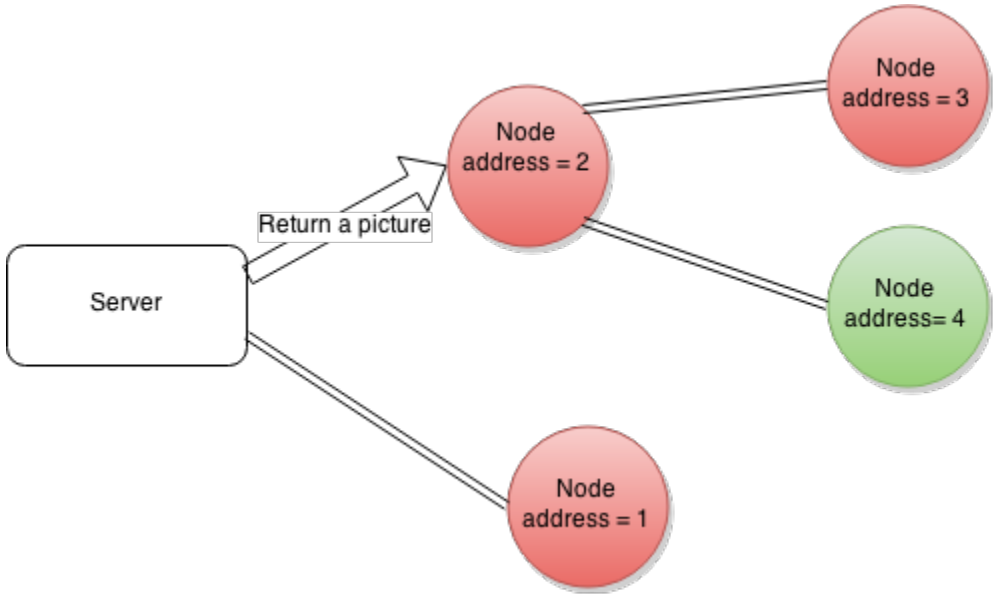
Finding and Pulling Pictures from the Network(14)



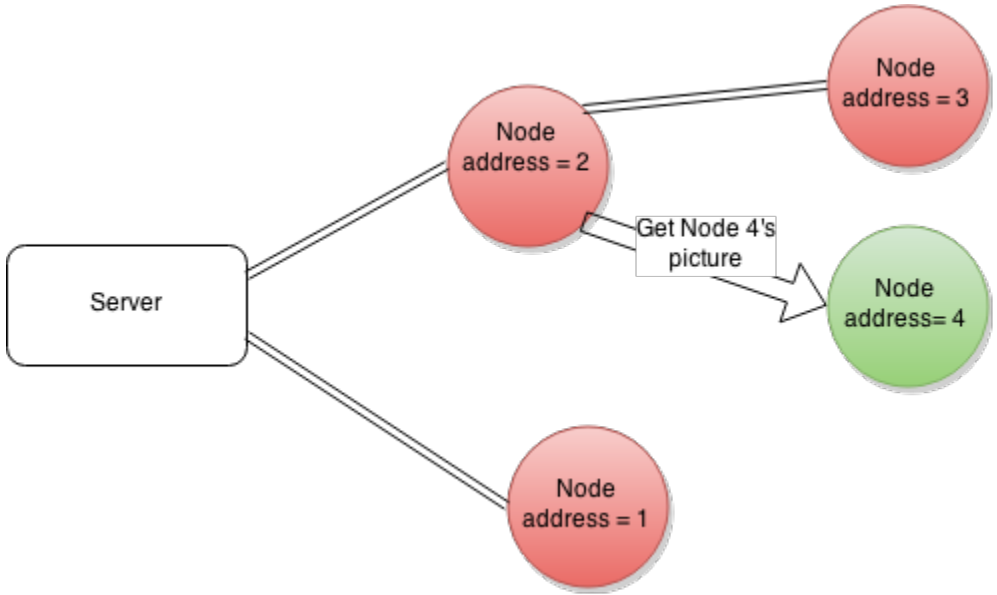
Finding and Pulling Pictures from the Network(15)



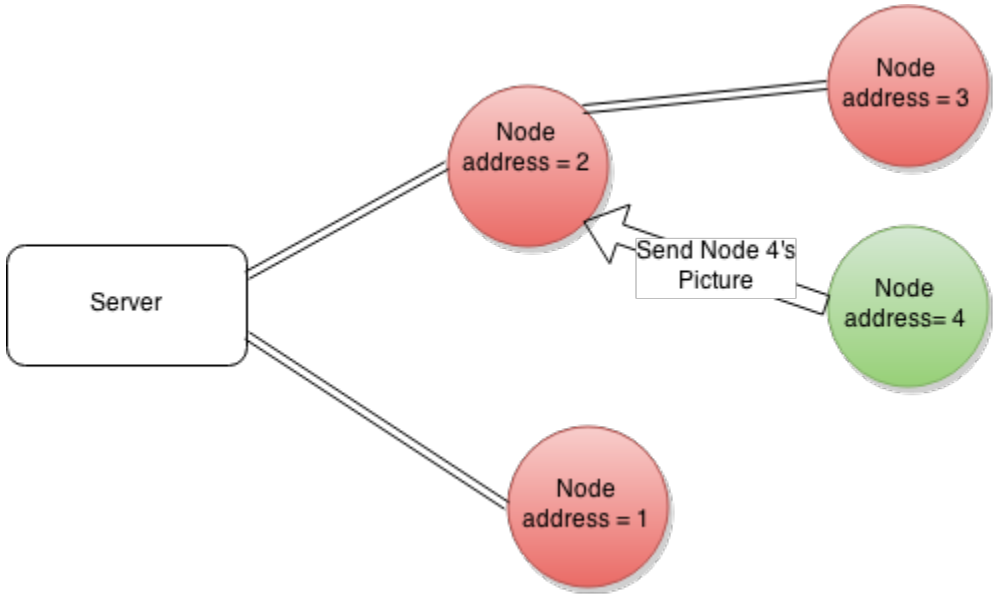
Finding and Pulling Pictures from the Network(16)



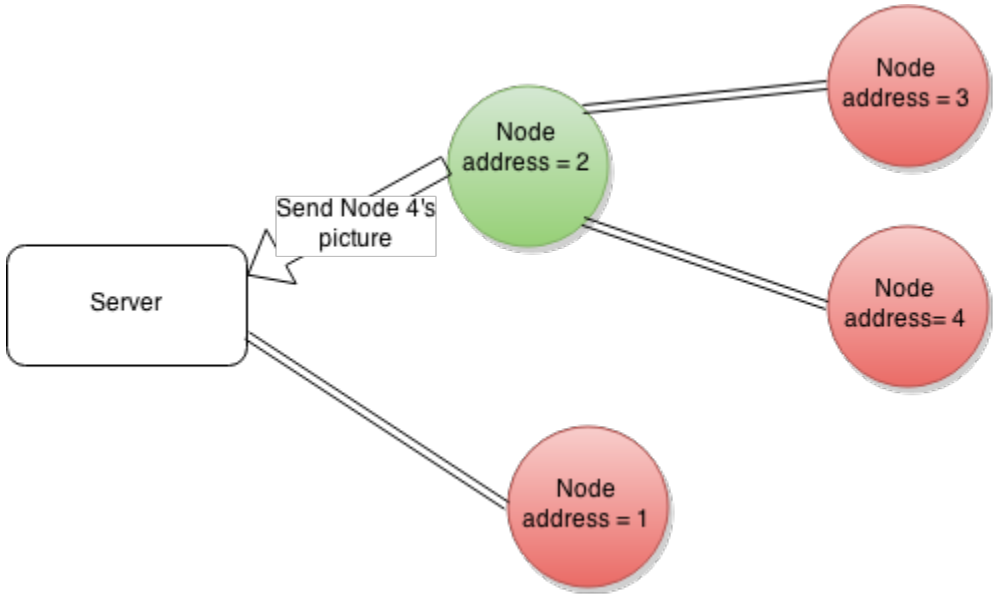
Finding and Pulling Pictures from the Network(17)



Finding and Pulling Pictures from the Network(18)

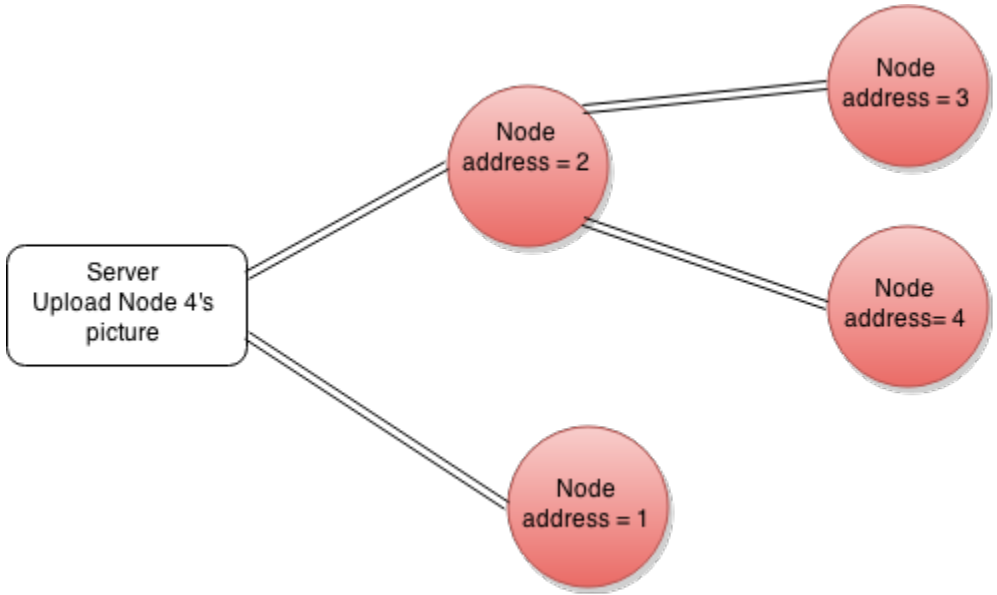


Finding and Pulling Pictures from the Network(19)



Finding and Pulling Pictures from the Network(20)

- Most time is spent transmitting/receiving pictures
- (.5 sec/ pic. transmission) × 4 pic. transmissions = about 2 seconds elapsed



Packet Specifications

Preamble	Header	Length of Packet	Data	CRC
4 Bytes	4 Bytes	1 Byte	1-64 Bytes	2 Bytes

- Preamble?
- The header contains node address, and other information relevant to the network
- Data field of the packet contains the picture data
- The CRC check on the transceiver checks for corruption

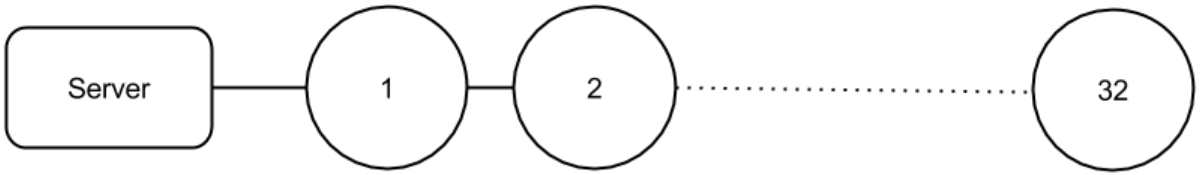
Previously Proposed Specifications:

- ❏ > 2 week battery life under normal conditions
- ❏ Network should support up to 32 nodes in a reasonable configuration
- ❏ Server should be able to easily add nodes (up to 32) using a user-friendly interface
- ❏ Network should account for packet loss
- ❏ Enclosure should be waterproof
- ❏ L.O.S. transmission range ≥400m

Measured Power Consumption of a Node

Modes:	Sleep	RX	TX
Current	160uA	38mA	330mA
Power	720μW	171mW	1.485W

Node configuration
Retrieval Time - Worst Case

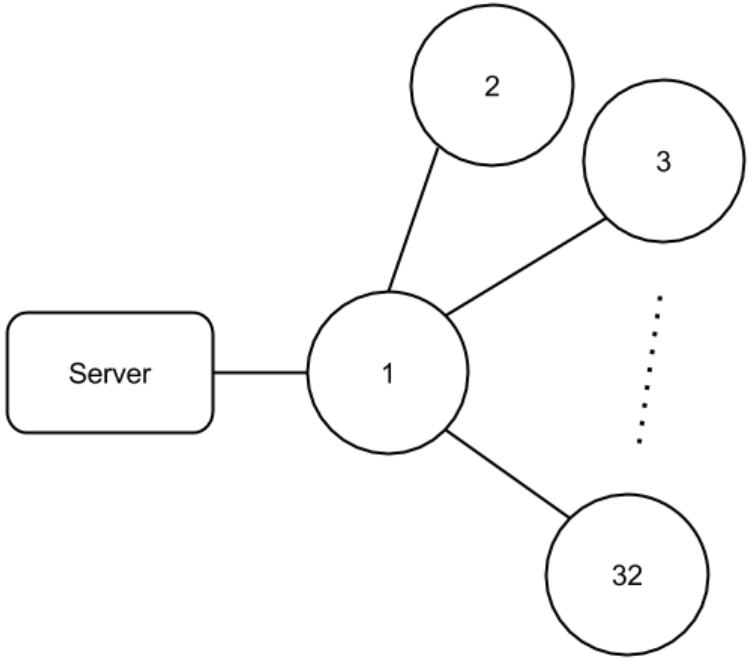


Assume all nodes have a picture.
Assume all time is spent transmitting/receiving pictures (good approximation for this case)
Time to transmit a picture ~ 17kB / 256kbps ~ 0.5sec

Total picture transmissions = 1+2+3+...+32 = 528
Time Elapsed = 528 × 0.5sec = 4 min 24 sec

This worst case is acceptable from a time perspective.

Power: Worst Case



Assume all nodes start with pictures and immediately obtain new pictures after network clear.

Node 1 spends (32/63) = 50.8% of the time in TX

Assume the rest is in RX mode = 49.2%

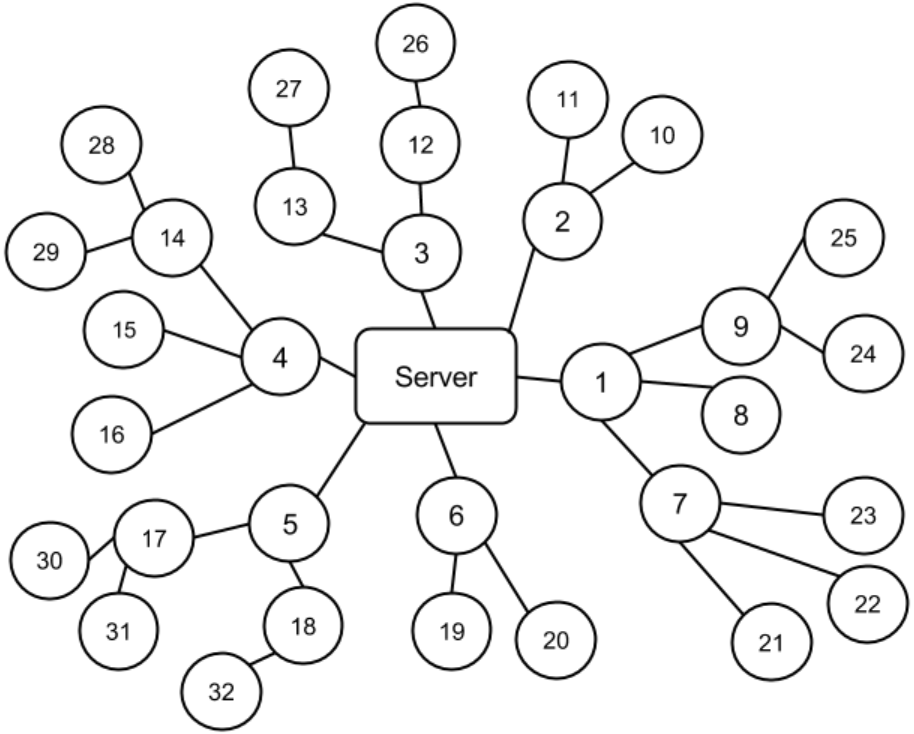
Ave. Current. ~ (.508)(330mA) + (.492)(38mA) ~187mA
With 3 D cell batteries at 15Ah each

Node 1 can operate for 15AH/187mA ~ 3.5days

This is somewhat reasonable.

Most reasonable configurations are well within spec.

Retrieval Time - Normal Configuration



Assume all nodes start with pictures.

Count hops needed from each node.
Sum of all hops = total transmissions

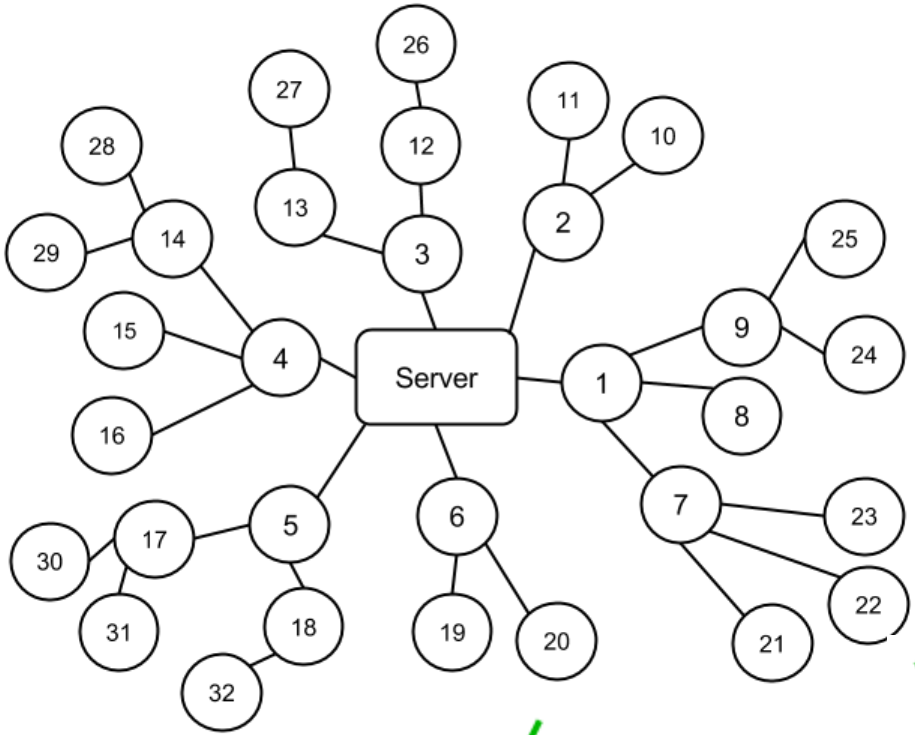
= 70 pictures TX/RX in this case

At ~0.5 sec / transmision

= 35 seconds worst case to clear the network for this configuration

This is very reasonable.

Power - Normal Configuration



Again Node 1 consumes the most power.

Assume all nodes have pictures, 35 sec to clear network, and nodes get pictures again right after the clear (unrealistic).

Total transmissions in branch = 22

Total transmissions = 70

Node 1 in sleep mode for (70-22)/70 = 68%

TX is (1 - .68)(9/22) = 13%

assume RX ~ 1 - .13 - .68 = 19%

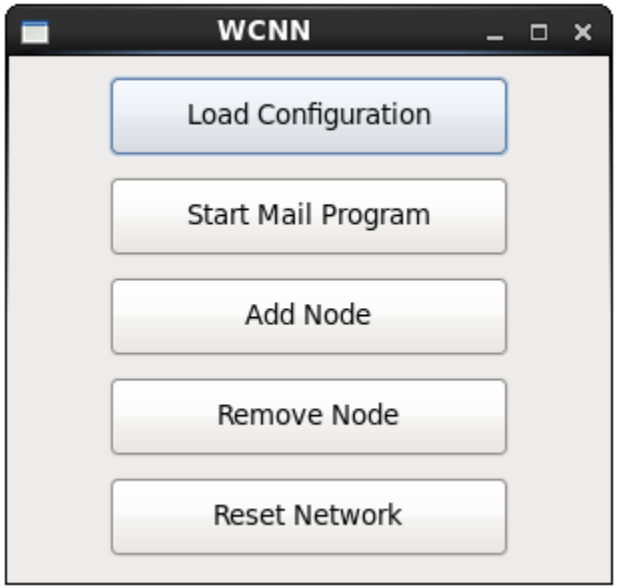
Ave Current = (.13)(330mA) + (.19)(38mA) + (.68)(160μA) ~ 50mA

15Ah/50mA ~ 13 days worst case

☑ > 2 week battery life under normal conditions

☑ Network should support upto 32 nodes in a reasonable configuration

Configuring The Network



To easily add nodes to a network, we have made a GUI to run on the Linux operating system.

Unfortunately this GUI has not been integrated with the Network

- [x] Server should be able to easily add nodes (up to 32) using a user-friendly interface

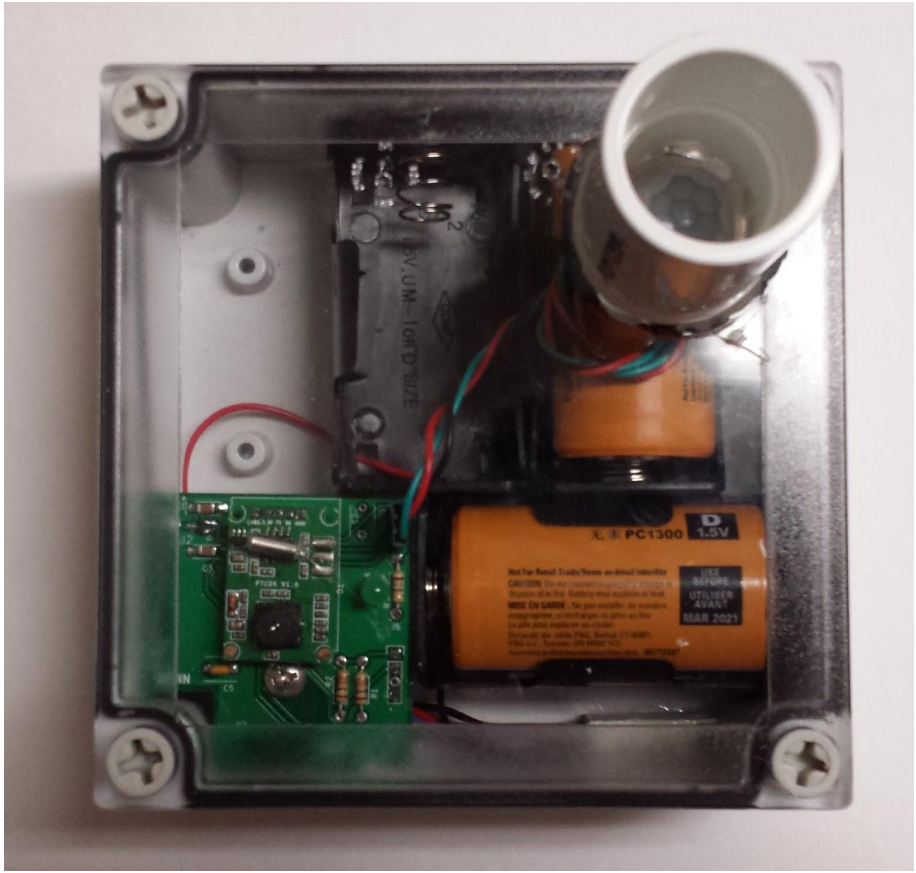
Accounting for Packet Loss

Timeouts and ACKs are used to sense packet loss. After an unsuccessful transfer, the packet is resent.

Future implementations would include sequence numbers.

Network should account for packet loss

Waterproofing



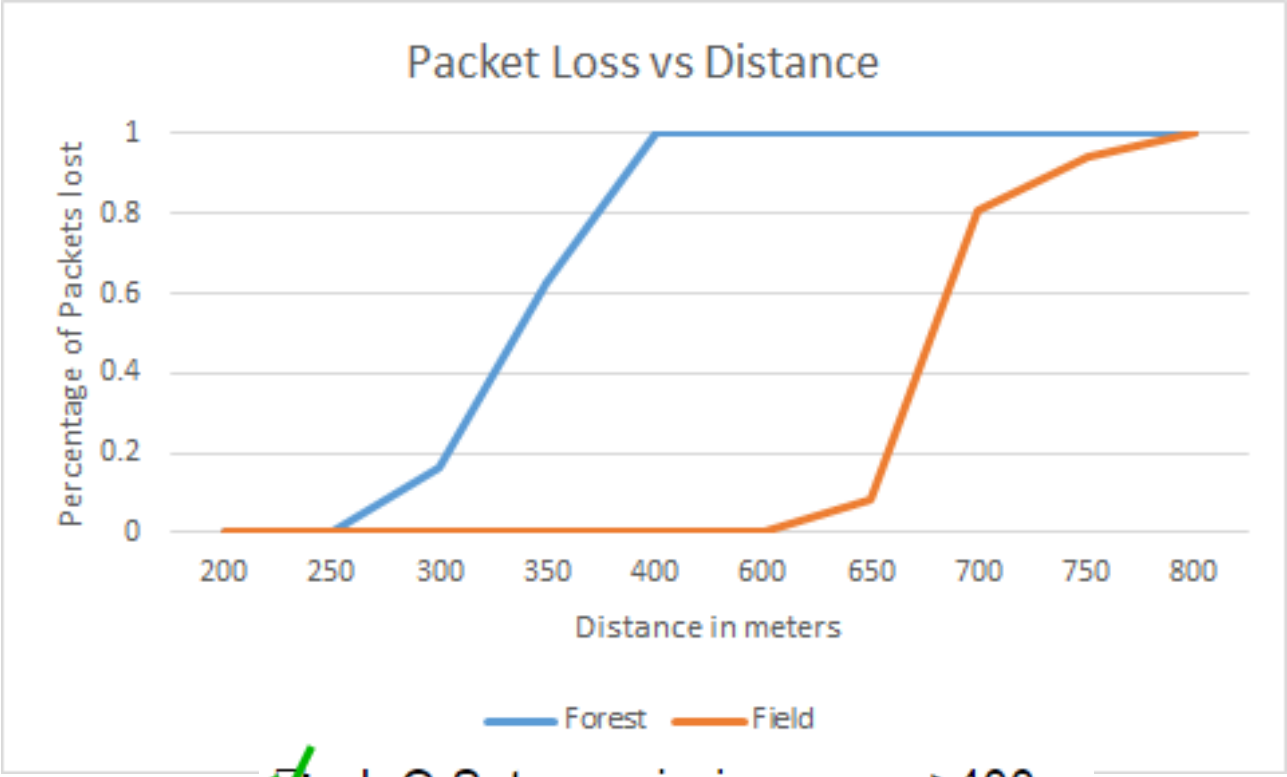
Rugged Off-the-shelf water-tight enclosure is used

Holes are drilled to expose the PIR sensor and the temp/hum. sensor

Epoxy resin is used as sealant

☑ Enclosure should be waterproof

Transceiver range over different terrains



☑ L.O.S. transmission range ≥400m

Bill of Materials

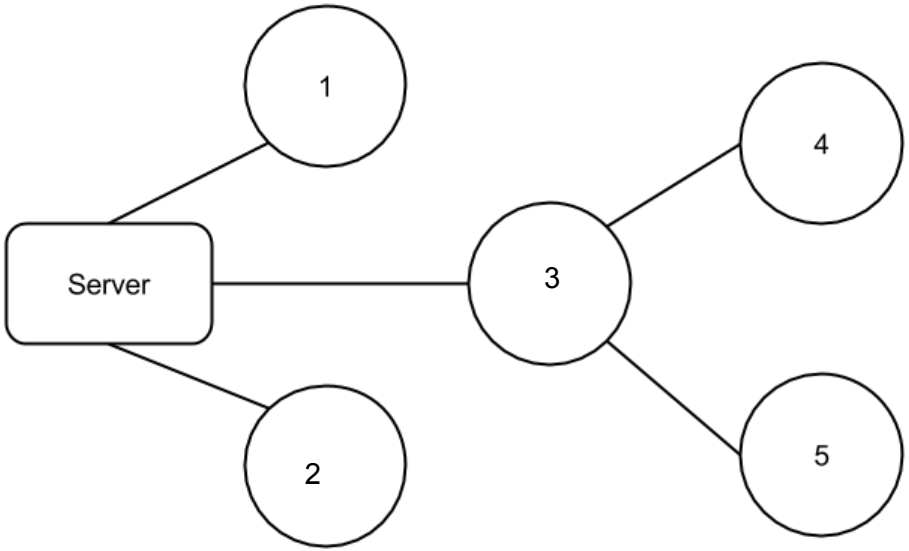
Component	Unit Price	Other Info
TTL JPEG Camera	$16.63	> 2 AliExpress
HopeRF RFM23BP	$8.80	From Anarduino
MaxDetect RHT03	$7.96	>100 Sparkfun
PIR Motion Sensor	$4.40	>10 DF Robot
PIC32MX170F256B	$2.94	>100 Mouser
Printed Circuit Board	$1.00	Most Manufacturers
Passive Components	$0.30	>1000 Mouser
MCP1700T3302E/TT 3.3V Reg	$0.28	>100 Mouser
Green 3mm LED	$0.18	>1000 mouser
pMOS Transistor	$0.15	>1000 Mouser
Total Per Node	**$42.64**	

☑ Low cost <$100 per node

Specifications Met

- [x] > 2 week battery life under normal conditions
- [x] Network should support up to 32 nodes in a reasonable configuration
- [ ] Server should be able to easily add nodes using a user-friendly interface
- [x] Network should account for packet loss
- [x] Enclosure should be waterproof
- [x] L.O.S. transmission range ≥400m
- [x] Low cost <$100 per node

Demo Node Setup



Pictures Being Uploaded

https://wcnnumass.wordpress.com/

Questions and Answers