



Self Healing “Single Phase Looped” Network

AUTOMATED RECONFIGURATION FOR POWER OUTAGE MANAGEMENT

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BACKGROUND

- ❖ Smart Grid
 - Uses artificial intelligence & communication technology
- ❖ Self Healing Network
 - ❖ Automatic system response & reconfiguration
- ❖ Automation
 - ❖ Improves reliability
 - ❖ Real-time monitoring & intelligent control
- ❖ Distribution Network
 - ❖ Radial Network
 - ❖ One source supplying various customer loads



BACKGROUND

Advisor

- Mr. Carlton Blue, Georgia Power Smart Grid Project Manager



- Lack of SCADA automation on the power grid for underground single line to ground fault



BACKGROUND

- ❑ Faults often occur on power distribution networks
 - ❑ Disrupts the customers' electricity supply
- ❑ About 92% of faults occur on single phase radial distribution lines
 - ❑ Residential & Small commercial
 - ❑ Decreases Utility Reliability Index
- ❑ \$119 billion annually
 - ❑ Reported by Electric Power Research Institute



CURRENT STATE-OF-ART

- ❑ Self-healing techniques

- ❑ 3 Phase

- ❑ Improv

- ❑ Radial

- ❑ Manual

- ❑ Back-f



e

open switch

outages

- ❑ Crew workers pinpoint and isolate fault

- ❑ Perform manual switching to isolate & minimize outage spans

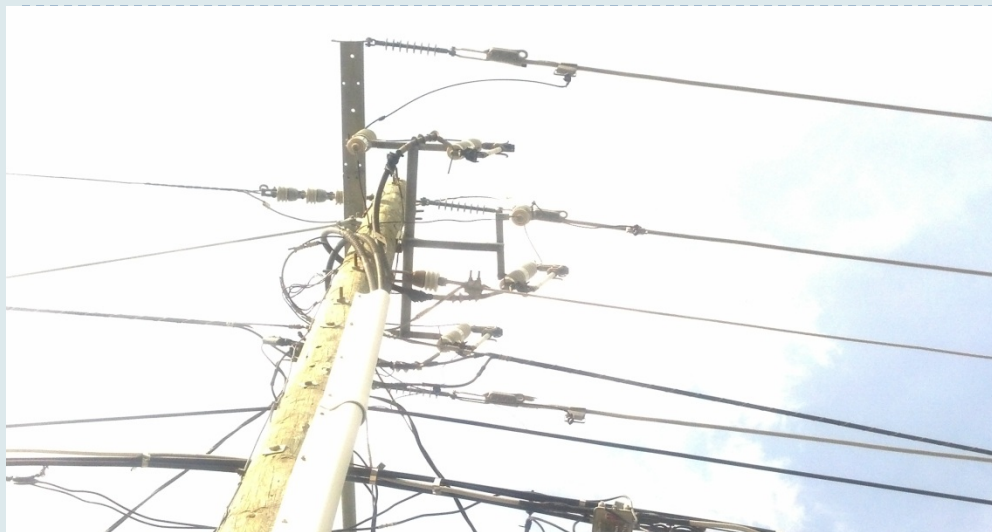


CURRENT STATE-OF-ART

- ❑ Self healing automation
 - ❑ Eliminates major impact of underground line faults
- ❑ Separate automated normally open switch
 - ❑ Reduce extended duration customer outages



CURRENT STATE-OF-ART



Single Phase Tap into a Large Apartment Complex

Single Phase Pad Mounted Transformer in Large Apartment Complex



PROBLEM DEFINITION

Design and create a software that would utilize Intelligent Electronic Devices (IEDs)

1. Sense & identify location of a single line to ground fault on a single phase radial network with fault
 2. Isolate faulted line section
 3. Reconfigure the network through the normal open to minimize the customer impacted by a forced outage
-

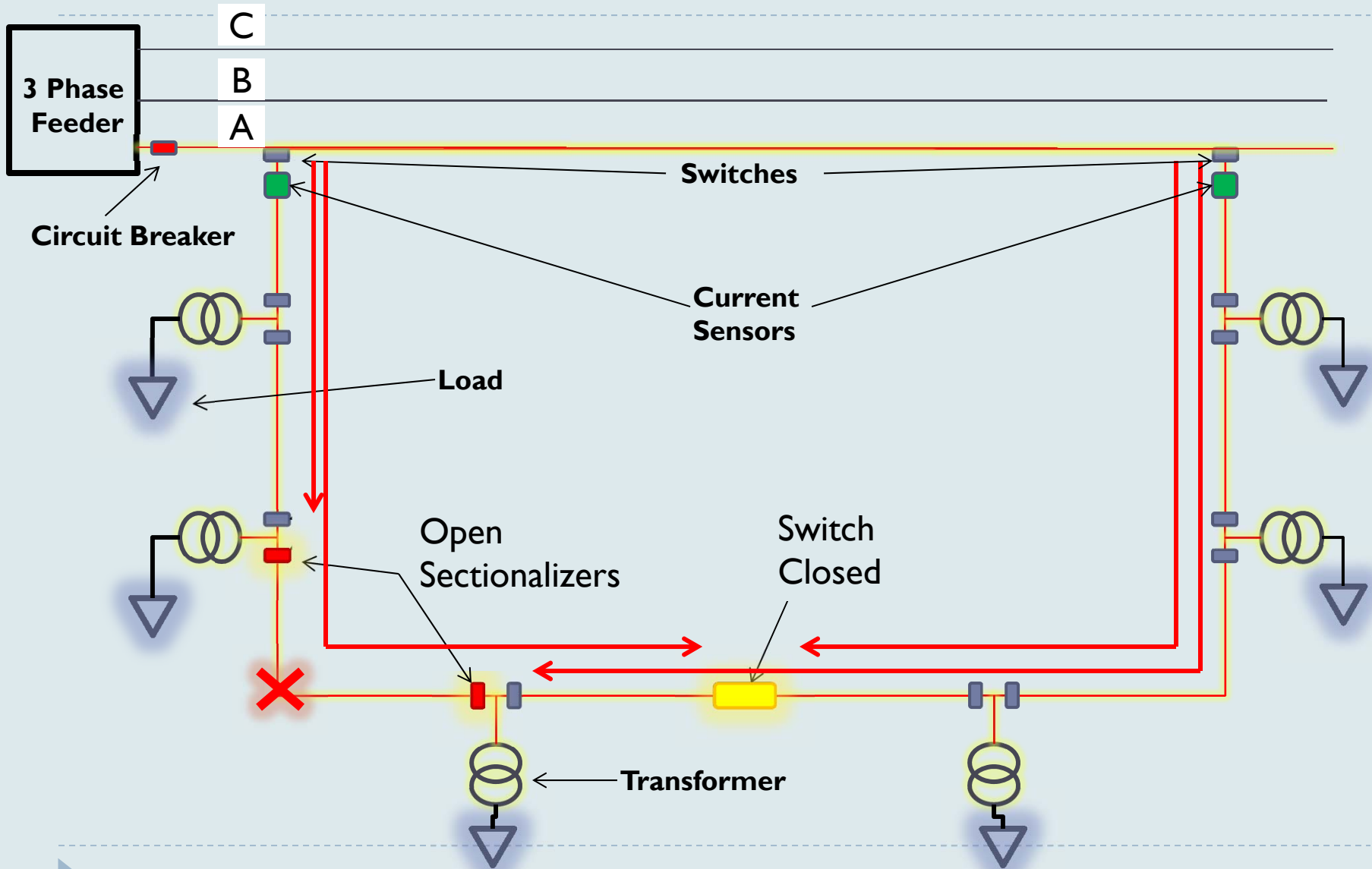


DESIGN REQUIREMENTS

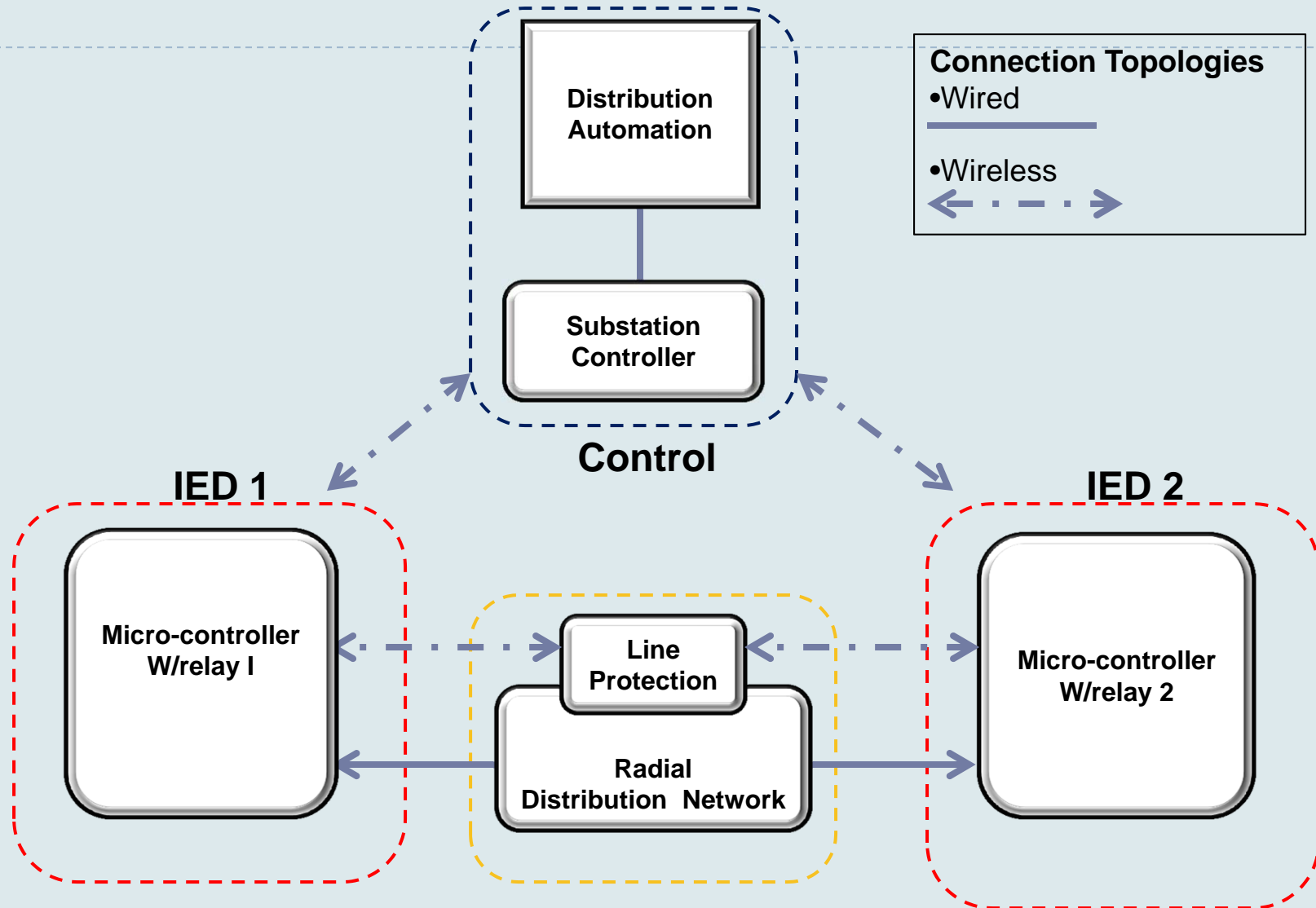
Function	Description
Fault detection and location	System must detect and locate single line to ground fault within $t \leq 10\text{ms}$
Line isolation	Relays must isolate faulted lines through circuit breakers within 1 min
Communication	Scheme must be operated wirelessly IED to Substation
SCADA	Continuously monitor network



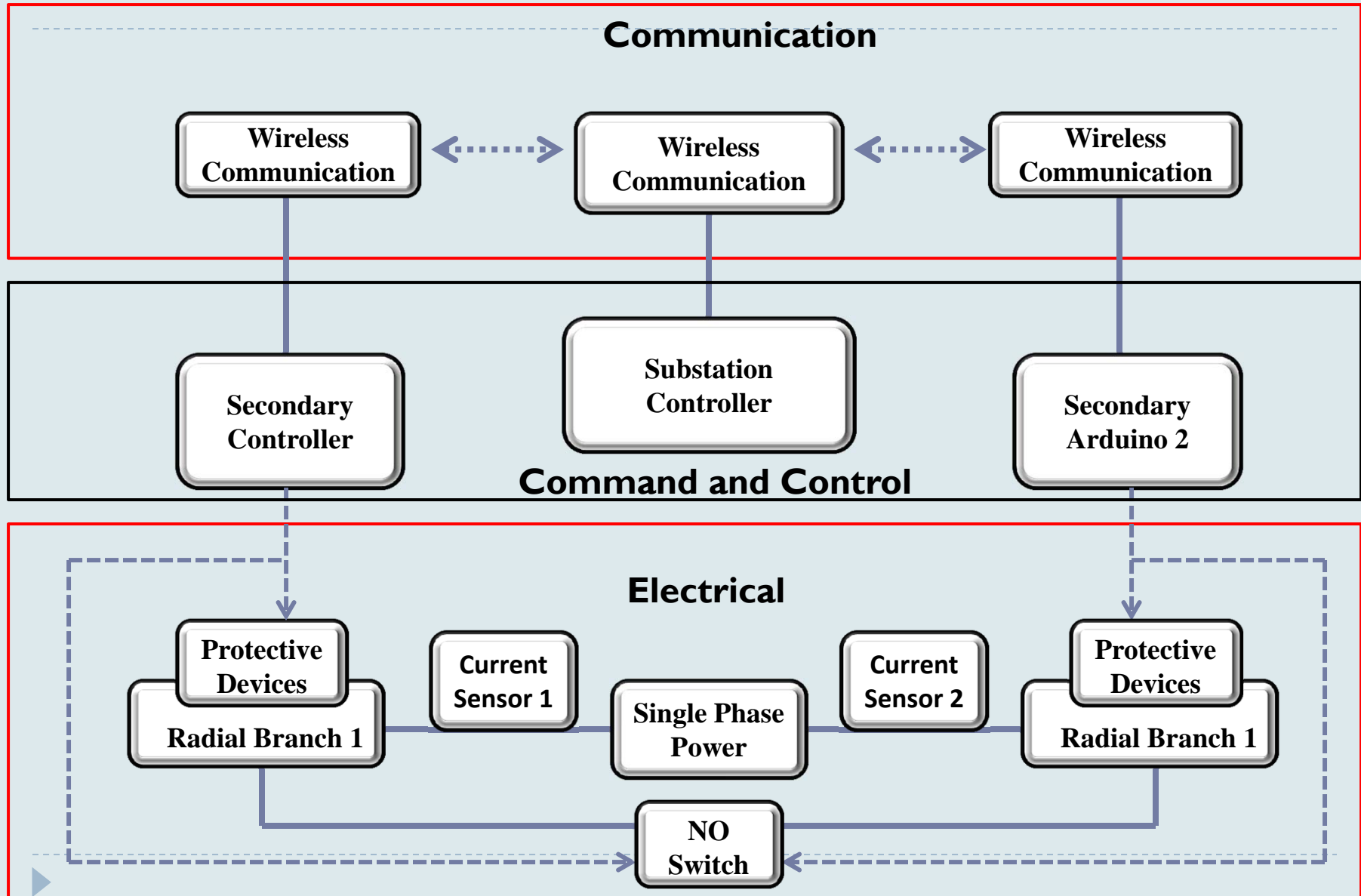
SOLUTION APPROACH



SYSTEM STRUCTURE



SYSTEM INTEGRATION



BENEFITS OF AUTOMATED RECONFIGURATION

- ▶ 5 faults in the year 2012
 - ▶ 3 faults on the transformers & 2 faults on the line
 - ▶ Average of 15 c.p.t. (5 transformers in the line)
 - ▶ Total Number of customers = 75
- ▶ Time to find a fault = 120 minutes (on average)
- ▶ Time to restore a fault = 120 minutes (on average)
- ▶ Customer Minute formula
 - ▶ Customer Minute = $120 \times \text{Total \# of customers}$
 - ▶ Customer Minute = $120 \times 75 = 9,000$ minutes (before fault location)
 - ▶ Customer Minute = $120 \times 45 = 5,400$ minutes (after fault location)
 - ▶ Total Customer Minutes = 14,400 minutes



TEST & EVALUATION

- ▶ Without Our Automation

- ▶ SAIDI = $\frac{\text{Sum of customer interruptions durations}}{\text{total number of customers}}$

- ▶ CAIDI = $\frac{\text{Sum of customer interruptions durations}}{\text{total number of customers interruptions}}$

- ▶ **SAIDI = $\frac{(120 \times 75) + (120 \times 45)}{150} = \frac{14,400}{150} = 96$ minutes**

- ▶ **CAIDI = $\frac{14,400}{75} = 192$ minutes**



TEST & EVALUATION

- ▶ With Our Automation

- ▶ $SAIDI = \frac{\text{Sum of customer interruptions durations}}{\text{total number of customers}}$

- ▶ $CAIDI = \frac{\text{Sum of customer interruptions durations}}{\text{total number of customers interruptions}}$

- ▶ **$SAIDI = \frac{120 \times 45}{150} = \frac{5,400}{150} = 36$ minutes**




- ▶ **-63%**

- ▶ **$CAIDI = \frac{5,400}{45} = 120$ minutes**

- ▶ **-39%**

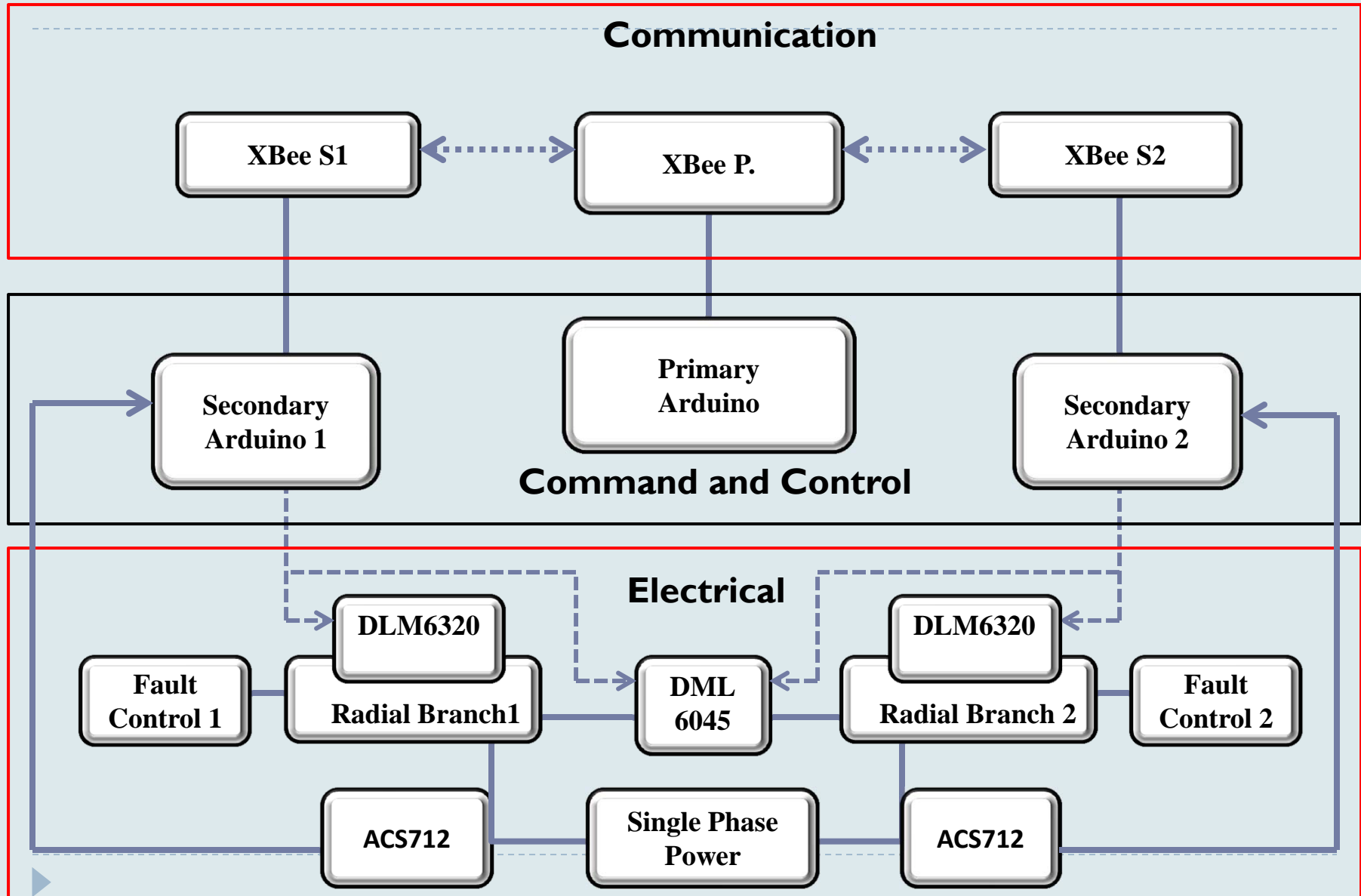


MAJOR COMPONENT & FUNCTIONS

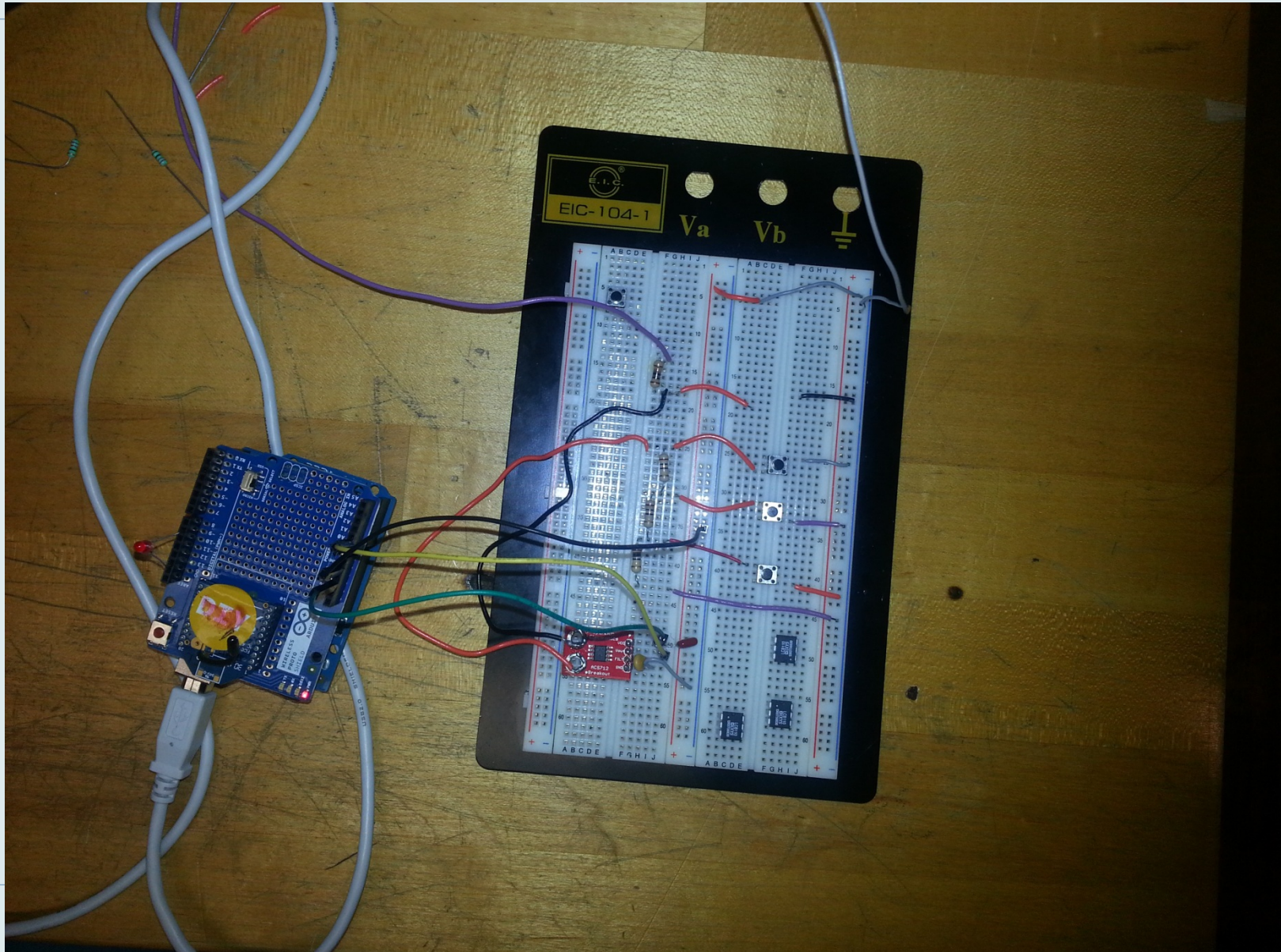
Compnts.	XBee Pro	ACS712	Arduino Uno	DLM6320	DML6045	Intel Atom
						
Category	•Wireless Transceiver	•Current Sensor	•Micro-controller	•Digital Switch NC	•Digital Switch NO	•Micro-Computer
Function	•Comm.	•Fault current reader	•Fault Detection, Isolation ,& Network Config. CTRL	•Line Protection	•Network Loop CTRL	•Network Analysis



DEMONSTRATION APPROACH



TESTING & EVALUATION



TESTING & EVALUATION

The image shows two windows from a serial communication software suite. The left window, titled 'COM5', displays a list of received data points: A10.23, A20.35, and A30.61, each repeated multiple times. The right window, titled '[COM23] X-CTU', shows a similar list of data points in red text, including A10.23, A20.35, and A30.61, with some lines starting with a period. The X-CTU window also features a control panel with 'Line Status' (CTS, CD, DSR), 'Assert' (DTR, RTS, Break), and other buttons like 'Close Com Port', 'Assemble Packet', 'Clear Screen', and 'Show Hex'. The status bar at the bottom of the X-CTU window indicates 'COM23 9600 8-N-1 FLOW:NONE' and 'Rx: 161 bytes'.

COM5 Window:

- Send
- A10.23
- A10.23
- A10.23
- A10.23
- A10.23
- A10.23
- A10.23
- A10.23
- A10.23
- A10.23
- A20.35
- A20.35
- A20.35
- A20.35
- A20.36
- A20.35
- A10.23
- A30.60
- A30.61
- A30.61
- A30.61
- A30.61
-
- Autoscroll
- No line ending
- 9600 baud

[COM23] X-CTU Window:

- About XModem...
- PC Settings | Range Test | Terminal | Modem Configuration
- Line Status: CTS CD DSR
- Assert: DTR RTS Break
- Close Com Port | Assemble Packet | Clear Screen | Show Hex
- A10.23
- .A10.23
- .A10.23
- .A10.23
- .A10.23
- .A10.23
- .A10.23
- .A20.35
- .A20.35
- .A20.35
- .A20.36
- .A20.35
- .A10.23
- .A30.60
- .A30.61
- .A30.61
- .A30.61
- .A30.61
- .A30.62
- ..A10.23
- .
- COM23 9600 8-N-1 FLOW:NONE Rx: 161 bytes

PARTS AND PRICES

	XBee Pro Kit 	ACS712 	Arduino Uno 	DLM 	DML 	Intel Atom 	Wireless XBee Shield 	Others .Rs,Cs .Wires .LEDs
Part No.	Kit-C-Xbee.24	BOB.0882	DEV.09950	LCB110	TLP222GF-ND	Intel Atom	MG.A00065	N/A
Qty	1	2	2	14	2	1	3	N/A
Vendor	Trossen Robotics	Sparkfun	Digikey	Digikey	Digikey	Dr. Kim	Newark	Lab
Price	\$79.95	\$9.96	\$24.95	\$5	\$3	\$0	\$24.95	\$0
Total	\$79.95	\$19.92	\$49.90	\$70	\$6	\$0	\$89.85	\$0

Grand Total

\$315.62

CONCLUSION

❑ Benefits

- ❑ Improve utilities SAIDI & CAIDI
- ❑ More reliable & robust distribution system
- ❑ Faults isolate & reconfigure during reclose cycle

❑ Future Work

- ❑ Ability to tap different phases (phase switching)



QUESTIONS?

