

s/Challenges/Opportunities in Building-level Power Management for Developing Economies

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What happens at SysNet ... shouldn't stay at SysNet!

Broad spectrum of systems research



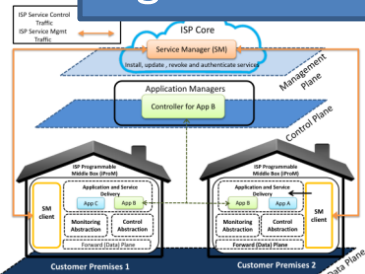
Funded by  & 

Computer Science

Electrical Engineering

SDN for ISP

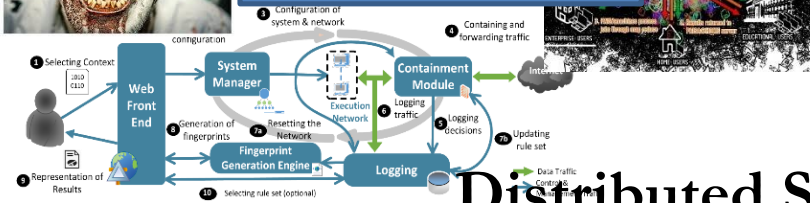
Sigcomm CCR



Botnets



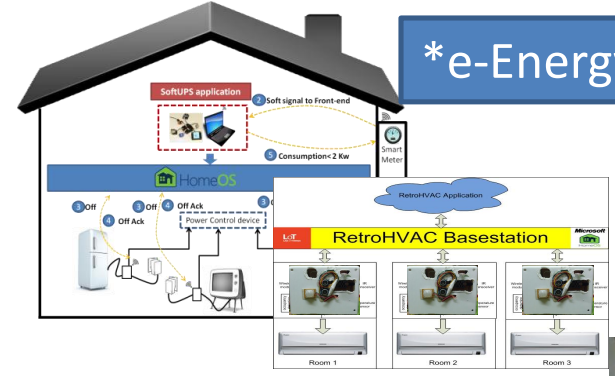
DSN, *S&P, *CCS



Distributed Systems

* = poster or demo

*e-Energy



Smart-home & Smart-Grid

Underwater networks

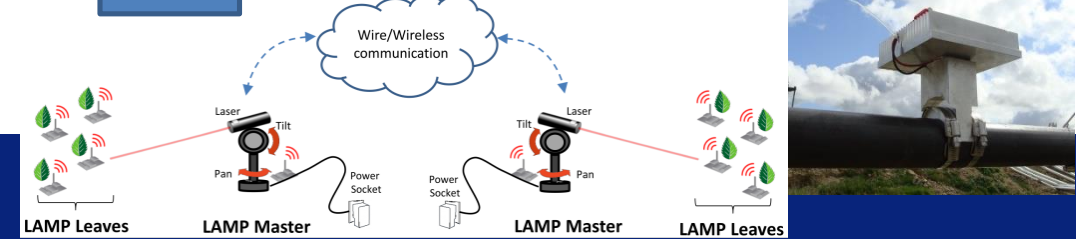


WUWNet

Energy harvesting and transference



IPSN



What I plan to do today

1. Bring an outside perspective to challenges/opportunities from my part of the world
2. Demonstrate two unique ways IoT/LoT can help address these challenges

The problems of here: Loss of *connectivity*

Lack of broadband has crippling effect

By Sharon Strover

http://www.utexas.edu/know/2011/04/08/strover_sharon_yonder/

Published: April 8, 2011

http://www.huffingtonpost.com/cp-Gurnani/the-role-of-connectivity-in-reshaping-the-world_b_4665180.html

The Role of Connectivity in Reshaping the World

Posted: 01/25/2014 10:39 am EST | Updated: 03/27/2014 5:59 am EDT

For many of us, the idea of leaving home without our mobile phone or tablet, or having no access to the Internet or to our e-mail, for any great length of time, is **unthinkable.** In today's tech-driven world, the latest electronic gadgetry -- be it a

OPINION INTERNET

The Internet As a Human Right

The Washington Times

Facebook's Zuckerberg: Web access a 'human right'



GOGO UNLIMITED
UNLIMITED
INTERNET ACCESS
WHEN YOU FLY

The advertisement features a white airplane flying over a blue and white background with a red and blue swoosh at the top left.

PROJECT LOON

WHAT IS LOON?

HOW LOON WORKS

WHERE LOON IS GOING



BALLOON-POWERED INTERNET FOR EVERYONE

The problems of *there*: Another loss of (power) connectivity



Load Shedding to Continue Across Maharashtra
<http://www.outlookindia.com/news/article/Load-Shedding-to-Continue-Across-Maharashtra/842950>

MUMBAI | JUN 02, 2014



Province: KwaZulu-Natal
City: Mandeni
Suburb: Equmeni
Month: 30-06-2014 to 27-07-2014

Home What is load shedding Interpreting schedules

1
Stage 1

Up to 1000 MW to be shed
From 06:00-22:30 Monday to Saturday

2
Stage 2

Up to 2000 MW to be shed
From 06:00-22:30 Monday to Saturday

3
Stage 3

Up to 4000 MW to be shed
24hrs from Monday to Sunday

Mon, 30 Jun	Tue, 01 Jul	Wed, 02 Jul	Thu, 03 Jul	Fri, 04 Jul	Sat, 05 Jul
-	20:00 - 22:30	-	10:00 - 12:30	-	20:00 - 22:30



Load shedding compounds summer heat

April 22, 2014 | Filed under: Electricity, Energy | Posted by: bdchronicle



The daily production of electricity has reportedly been reduced to bring down the cost of buying power from rental plants

Last summer (2013) it got really bad in Pakistan!

DAWN.com
 Sui Northern suspends supplies for industrial, CNG sectors
 December 11, 2013 | Safar 7, 1435
 HOME LATEST PAKISTAN WORLD SPORT BUSINESS SCI-TECH ENTERTAINMENT MULTIMEDIA
 OPINION IN-DEPTH ARCHIVE

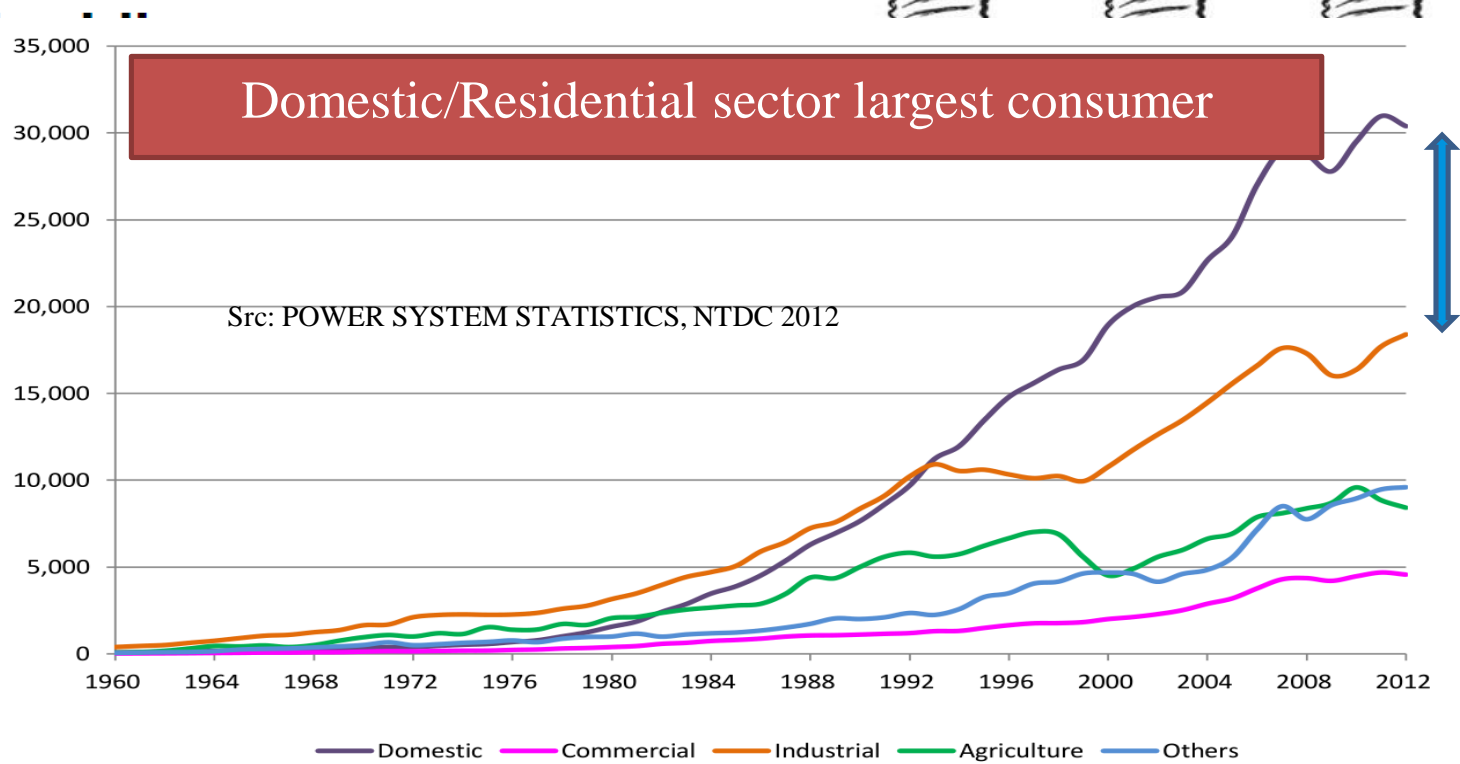
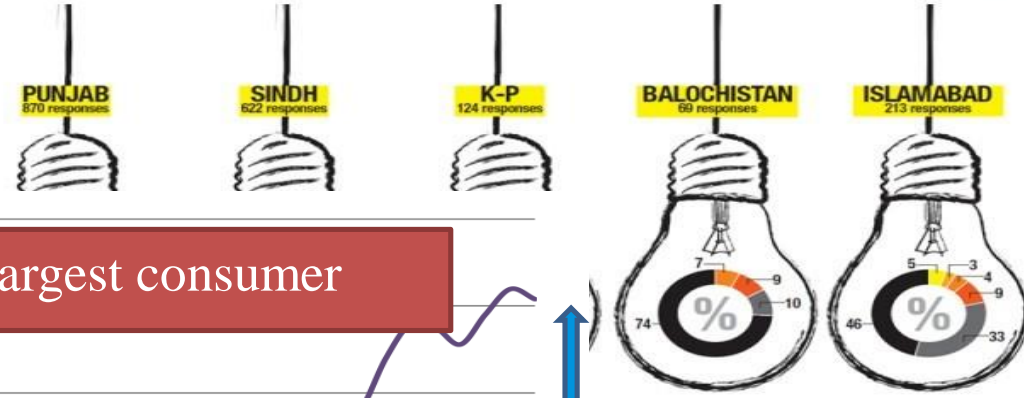
Home Newspaper Lahore

14 to 18-hour loads

THE NEWSPAPER'S STAFF REPORTER
 Like 0 Tweet 0 +1 0 Share

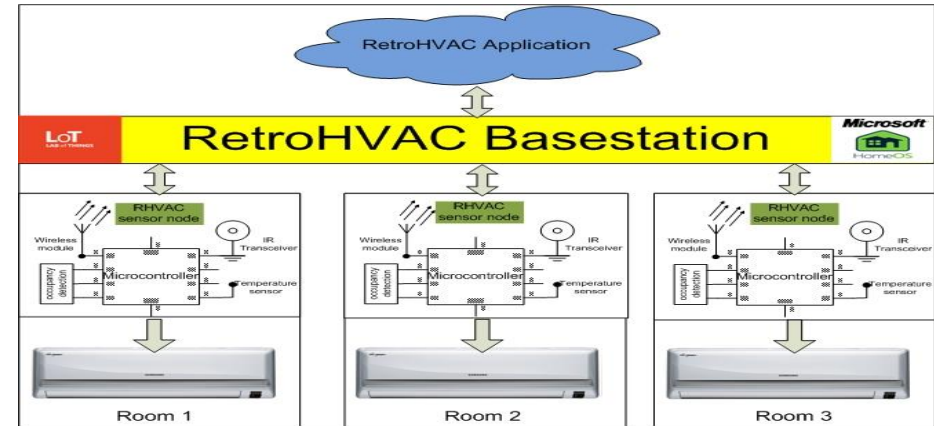
LAHORE, April 16: With weather warming for electricity has risen above 14,000MW 9,000MW. As a result, urban feeders are loadshedding and rural ones close to 18

THE EXPRESS TRIBUNE
 WITH THE International New York Times



Agenda

1. Removing the inefficiencies of UPS backups
2. Reducing consumption in old office buildings



Both using an IoT inspired, LoT enabled instrumented home

SoftUPS: Softening the impact of UPS backups



Local energy backups: managing load-shedding



Naïve soln: store energy from grid; use to power *essential* appliances during *load-shedding*



Load shedding



In effect we move to our homes, voluntarily to a low power state

Problems of a UPS+battery backup

Consumer

- Cost (initial \$300, recurring \$100*)



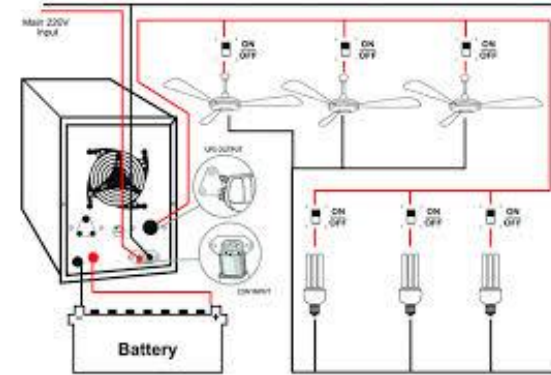
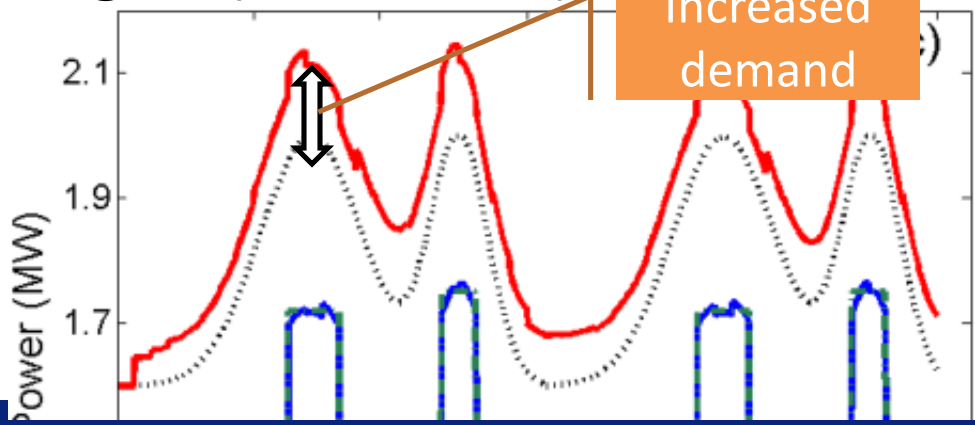
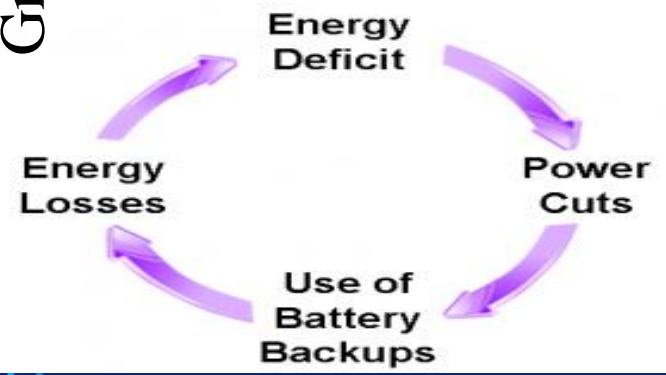
- Limited capacity



- Rigid selection of appliances (hard-wired)

Grid/Govt

- Increased total load on grid (inefficient)

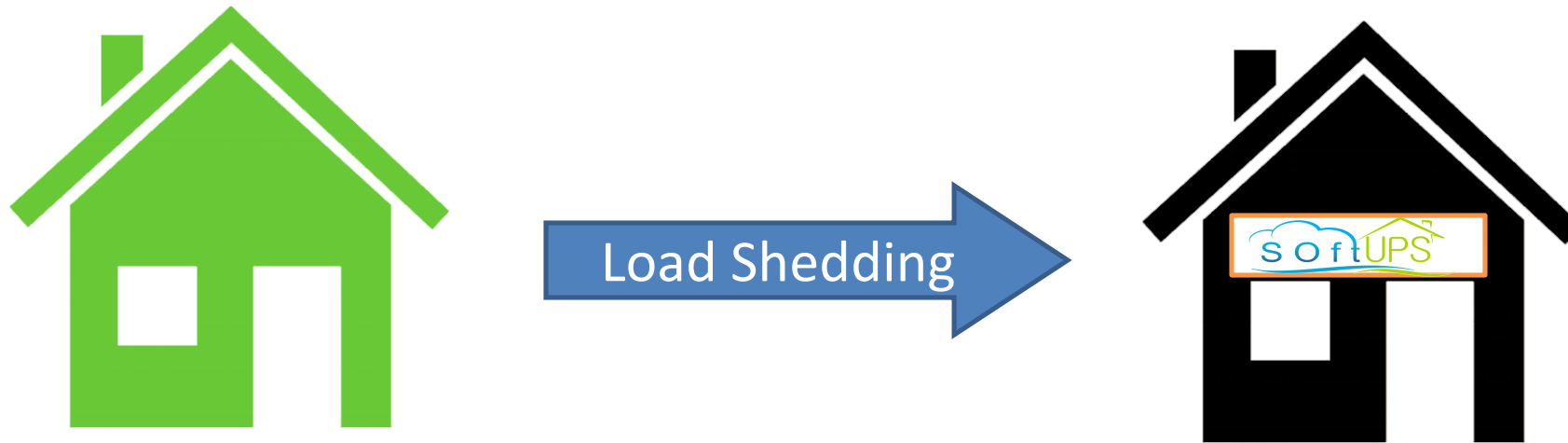


Src: askmohsin.com

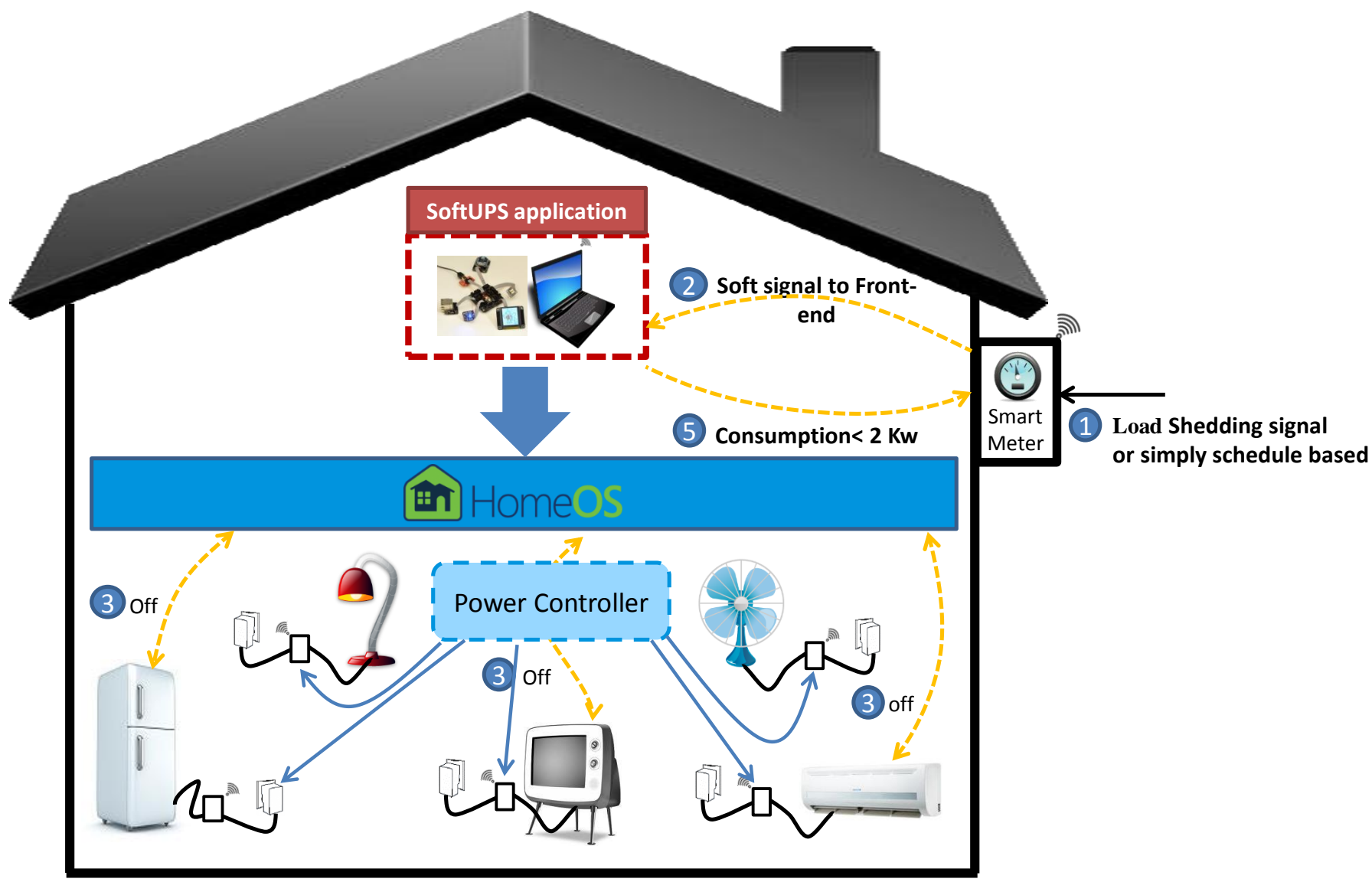
“Hidden Costs of Power Cuts and Battery Backups” in e-Energy’13, May 21–24, 2013

Key Idea for SoftUPS


- When demands need to be shed, why not *emulate* low power mode of a UPS-based soln?
 - **Something** enforces homes to operate at a lower power state
 - But operate directly off the grid!



SoftUPS: Architectural Overview using HomeOS/LoT



Benefits of SoftUPS

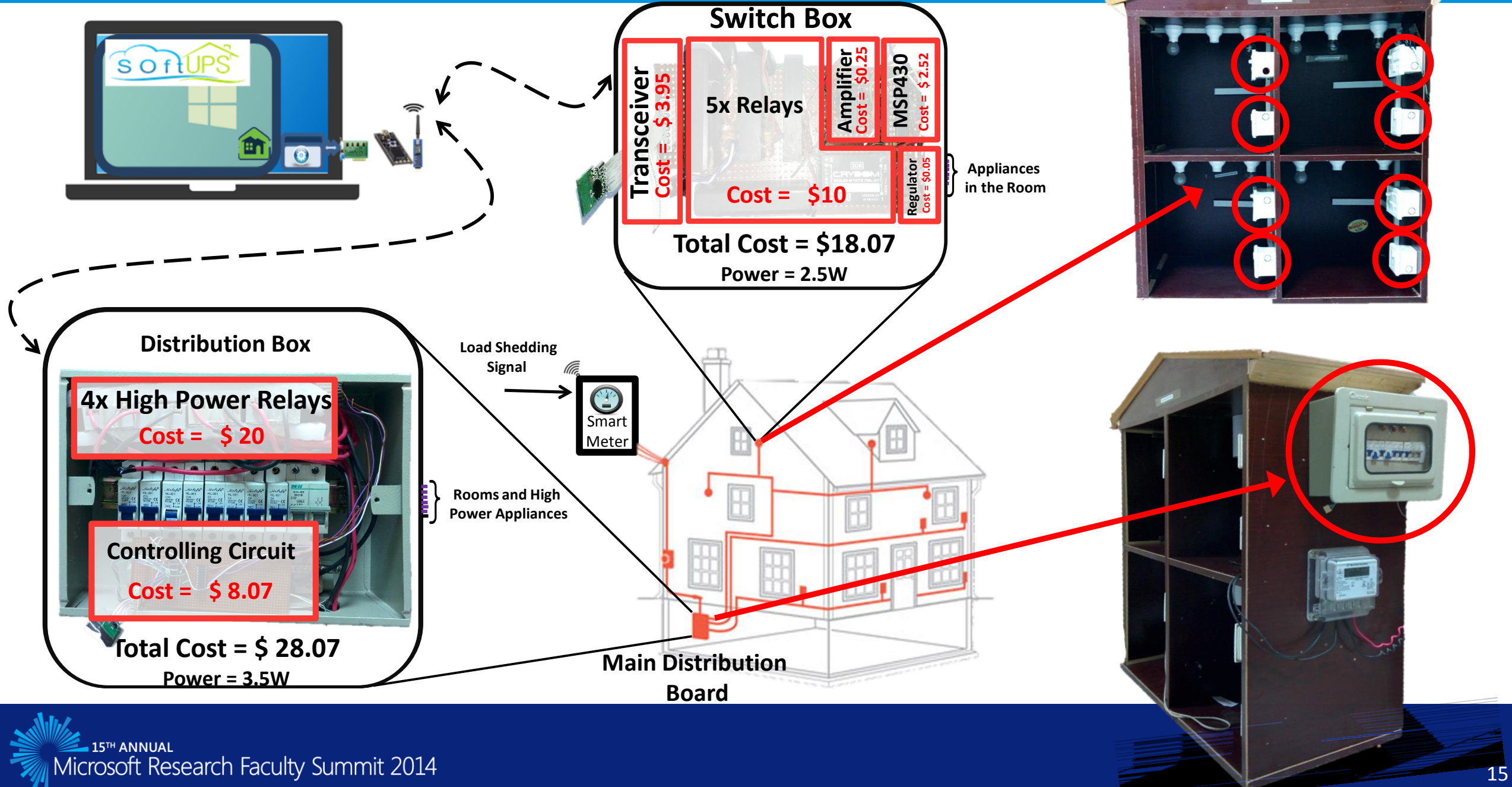
- One time cost
 - No efficiency losses
 - No resource exhaustion
 - Dynamic reallocation of power budget
- 
- A blue and white battery with a red 'X' over it, indicating it is not recommended or is a resource to be avoided. A blue bracket on the left side of the battery points to the first three bullet points of the list.

Bonus: implement cost-saving and green policies within home

Challenges

- **Deployment and practical concerns**
 - Worrying about power dissipation and consumption
- **Device and system cost**
 - Keep the cost of entire solution under \$300
- **Power theft and accidental misuse**
 - Detection and response
- **Application interface for usability**
 - Motivation and incentives for its usability

Wiring and Deployment



A demo video

- A virtual home with standard wiring
- We show
 - Device control
 - Load-shedding configuration and its emulation
 - Overage/misuse response



Research Enabled: The road ahead

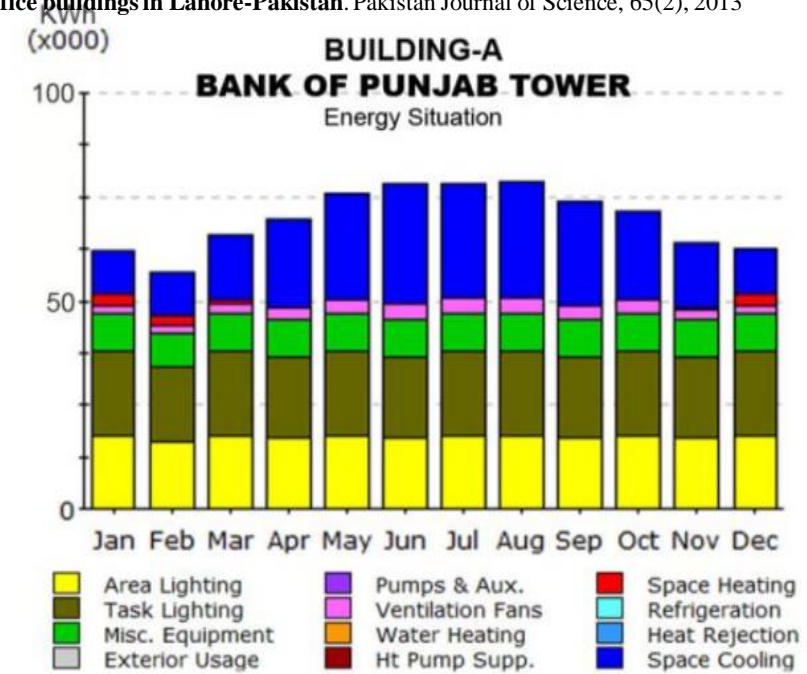
- Power “*congestion control*” algorithms with an automated demand control implemented at home
 - Fully distributed, coordinated, peer-based etc
- Optimal load shedding schedules
 - With different penetration of SoftUPS vs traditional UPS

RetroHVAC: HVAC for old buildings

Old buildings have distributed HVAC elements

- Ventilation (fans)
- Cooling (ACs)
- Heating (Space heaters)

A Khan, S Arif, M Mushtaq, et al. **Electricity consumption for energy conservation in office buildings in Lahore-Pakistan.** Pakistan Journal of Science, 65(2), 2013



<http://www.wahid-industries.com/>



<http://hvacmariettaco.com/ductless-mini-split-air-conditioning-systems.html/>



Scenarios of misuse/waste

Load Shedding



Leaving AC on,
inadvertently or
laziness

Scenarios of misuse/waste

Temp set
point = 18°C



Setting very low
threshold;
Lack of concern

Why not use HVAC to solve these problems?

Centralized HVAC system can solve such wastages, but:

- Large capital cost + inconvenience
- Waste of existing distributed elements

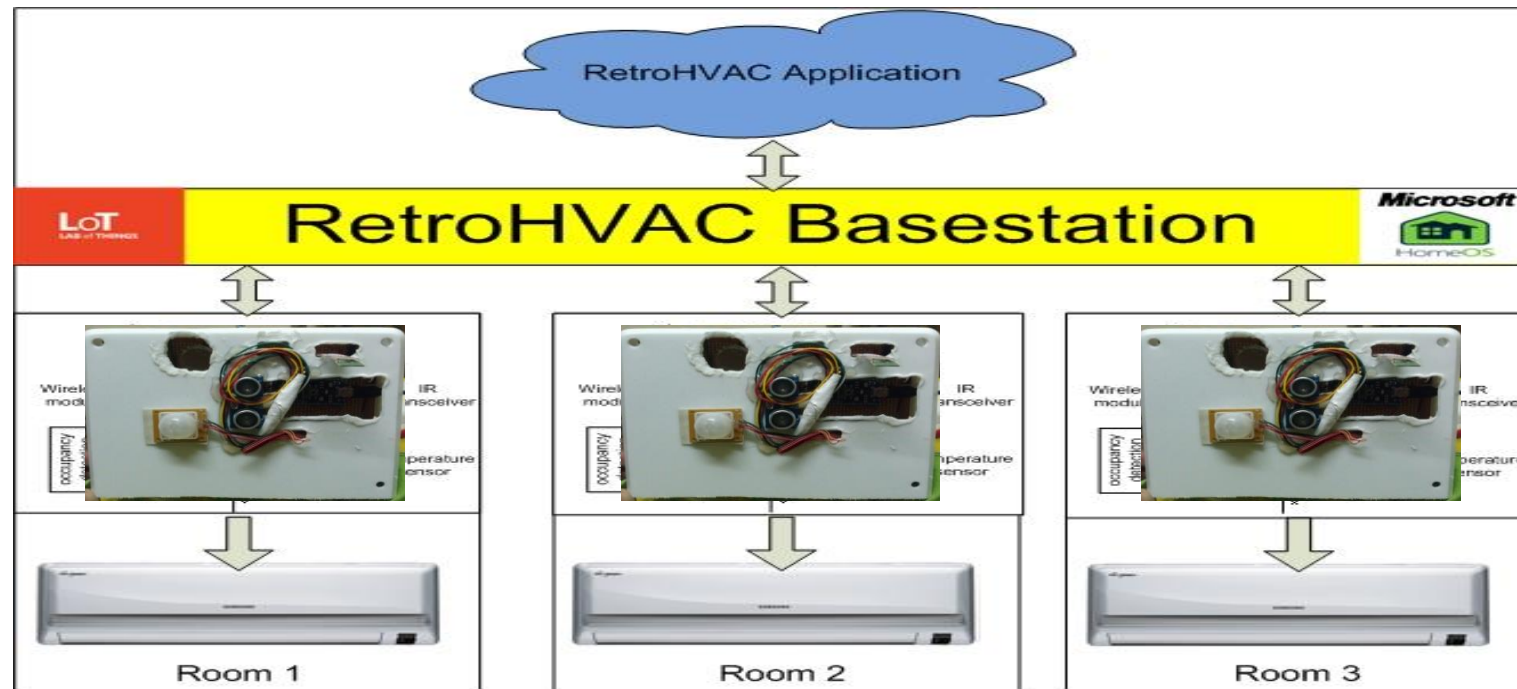


[http://www.homeadvisor.com/rated.Mc/rehouseImprovements.1333774](http://www.homeadvisor.com/rated/Mc/rehouseImprovements.1333774)



Retrofit elements for centralized control

- Retrofit existing elements with control and communication
 - Additionally add occupancy sensors
- Centralize command to enforce energy policies and ASHRAE standards



Architecture and Implementation Overview

■ Three components of RetroHVAC

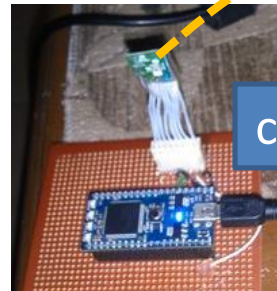
– Control nodes

- Occupancy and temp detection
- Actuation of AC
- Communication

– Base station

– Application

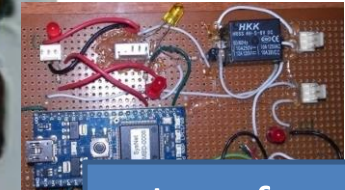
- Policy enforcement



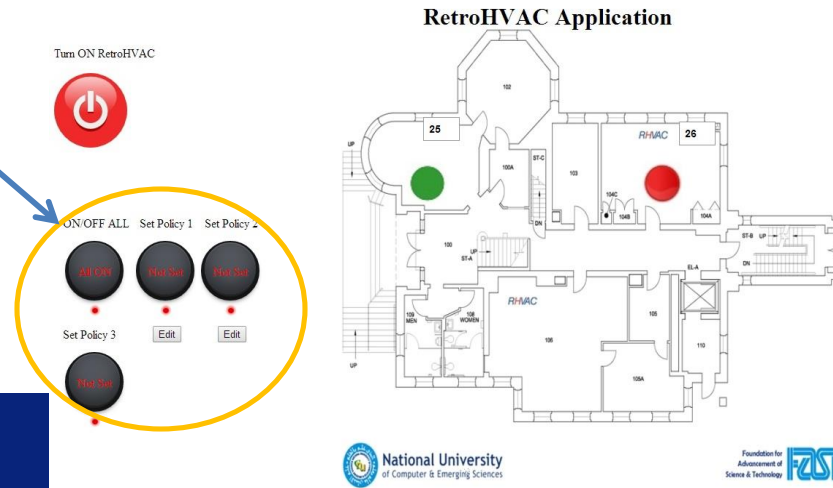
cc2500



PIR, light, ultrasound,
and temp sensors



Interface with
remote



Evaluation of savings

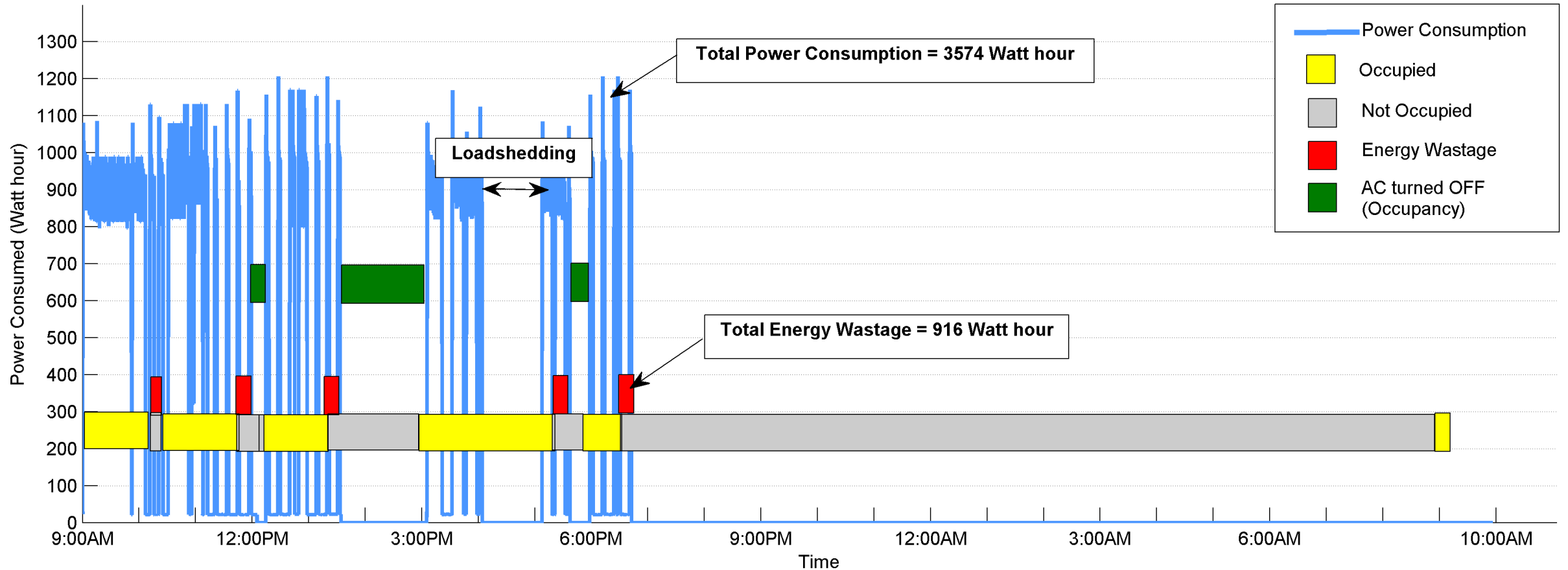
- Three policies
 - Static time based
 - Temp Control (+Static)
 - Occupancy based (+Temp+static)
- Base day consumption for a faculty office
- Comparison with savings for different policies under real evaluation



Energy Savings

Base Day

24-Hour Power Consumption of an Air Conditioner using RetroHVAC Occupancy Based Policy (23rd May 2014, Temperature=32C)



67.1% savings from base (AC on) day, 33.7% for a normal day

What are the wider implications of such work?

- Connected buildings can provide an alternate (shorter?) path to radically improve living standards in developing economies
 - Novel application for this context
- Maturing technologies and bleed back
- IoT frameworks allow focus on impactful applications

For more information

<http://sysnet.org.pk/>

email: affan.syed@nu.edu.pk

Thinking smartly, “*Smart*”-ness can be a
life-changer for some!

Questions

