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

Affan A. Syed

Associate Professor

Systems and Networking (SysNet) Research Lab,

Department of Electrical Engineering,

FAST-NUCES, Islamabad Campus

Acknowledgements: Zohaib Sharani, Noman Bashir, Khusboo Qayyum, Naveed Bhatti, and Aftab Rashid

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

SysNet System and Networking Research Lab

National University of Computer and Emerging Sciences

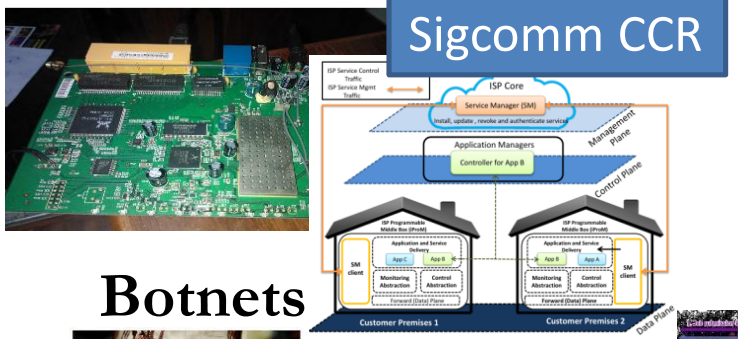
Broad spectrum of systems research

Funded by National ICT R&D Fund & Microsoft Research

Computer Science ⟵ ⟶ Electrical Engineering

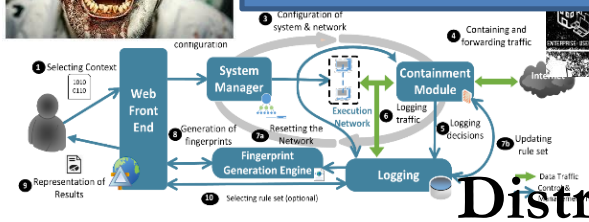
SDN for ISP

Sigcomm CCR



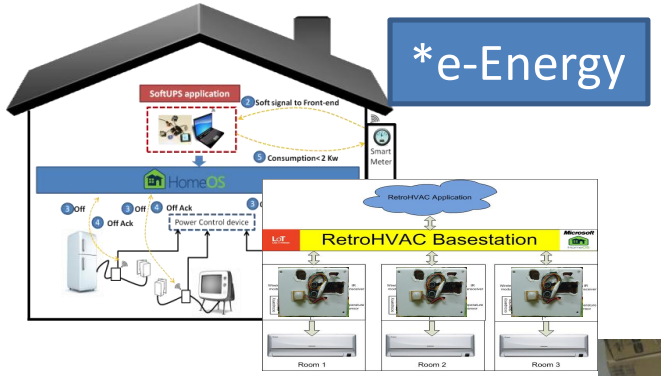
Botnets

DSN, *S&P, *CCS



Distributed Systems

*e-Energy

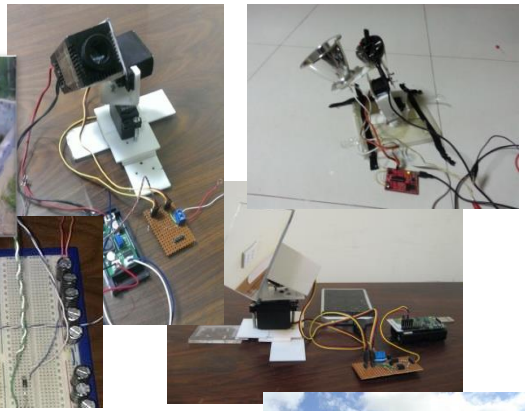


Smart-home & Smart-Grid

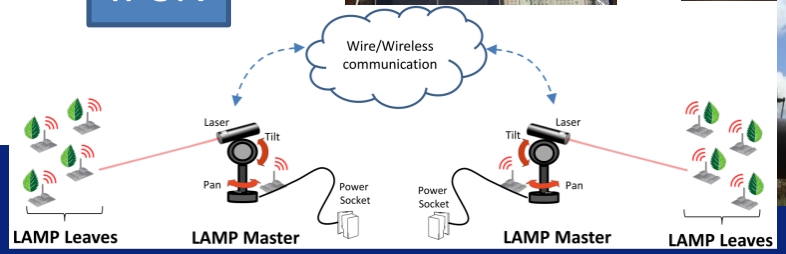
Underwater networks

WUWNet

Energy harvesting and transference



IPSN



*= poster or demo

15TH ANNUAL Microsoft Research Faculty Summit 2014

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
Published: April 8, 2011

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

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 ED

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'

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

Eskom | Powering your world

Home | What is load shedding | Interpreting schedules

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

1	2	3
Stage 1	Stage 2	Stage 3
Up to 1000 MW to be shed From 06:00-22:30 Monday to Saturday	Up to 2000 MW to be shed From 06:00-22:30 Monday to Saturday	Up to 4000 MW to be s 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

Google play

Load shedding compounds summer heat

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

THE BANGLADESH CHRONICLE™

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 MULTIME

OPINION IN-DEPTH ARCHIVE

Home Newspaper Lahore

14 to 18-hour loads

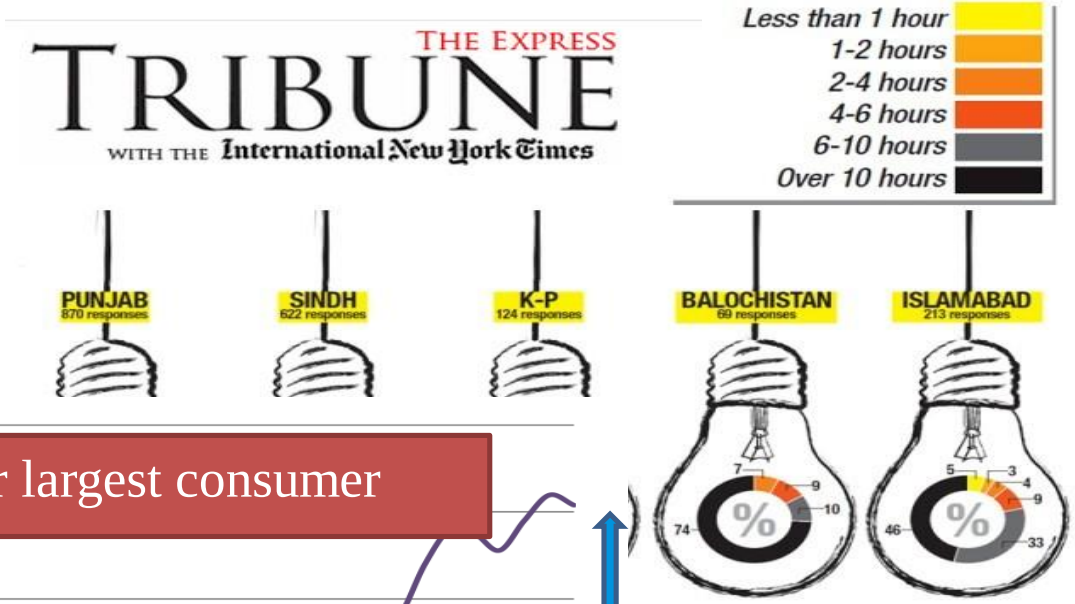
THE NEWSPAPER'S STAFF REPORTER

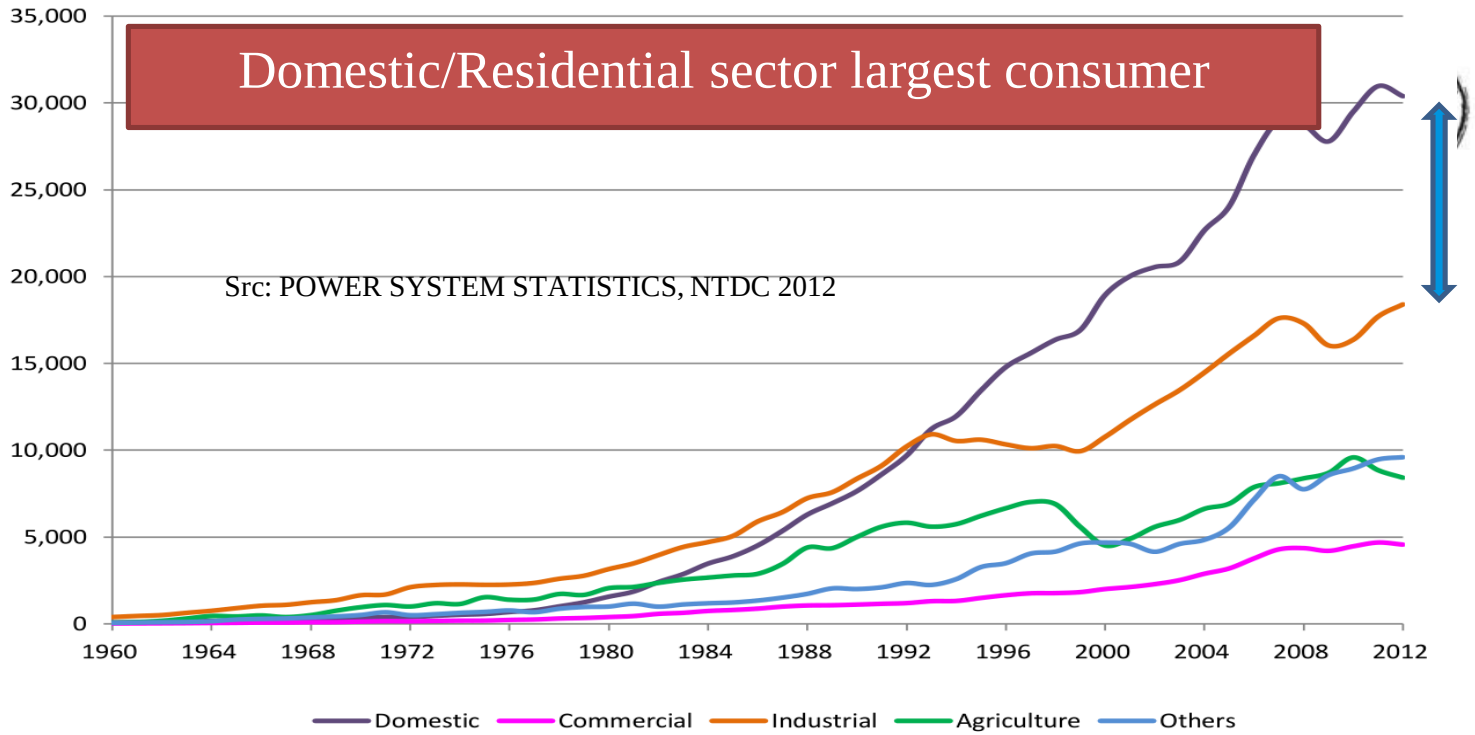
Like 0 Tweet 0 +1 0 Sh

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

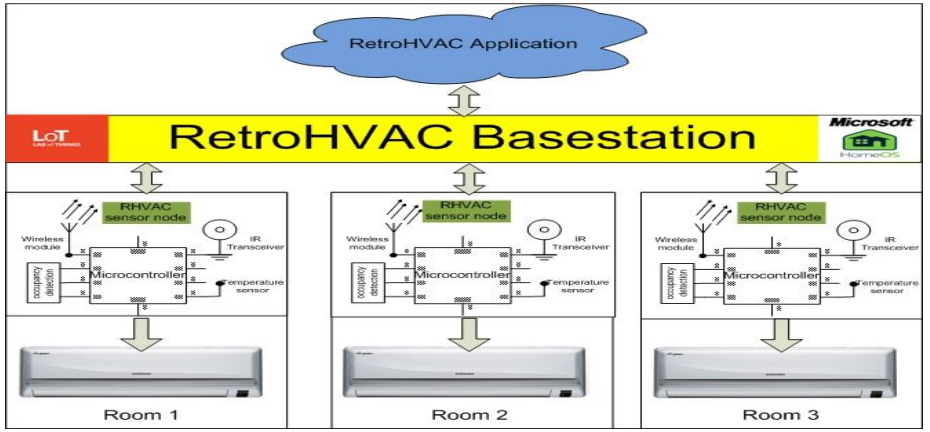




Src: POWER SYSTEM STATISTICS, NTDC 2012

Agenda

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

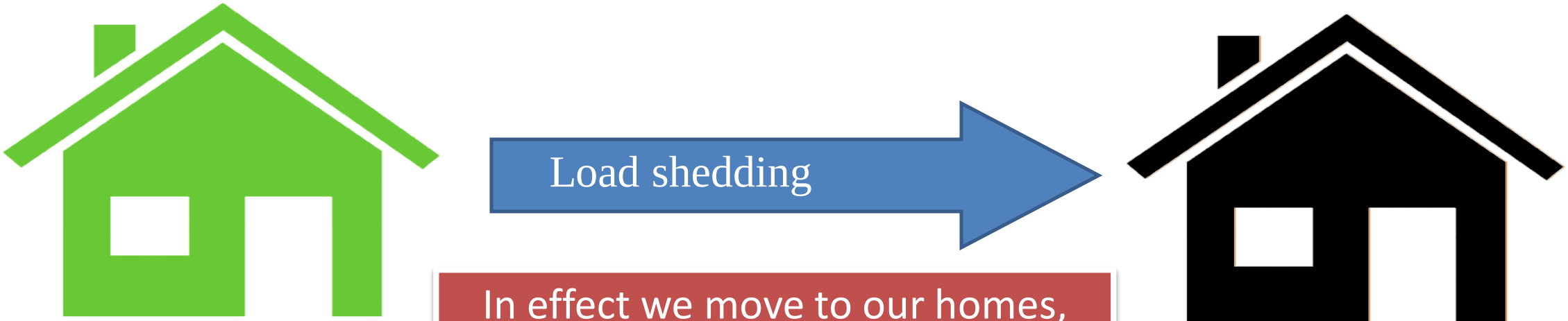


Both using an IoT inspired, LoT enabled instrumented home

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*



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

Problems of a UPS+battery backup

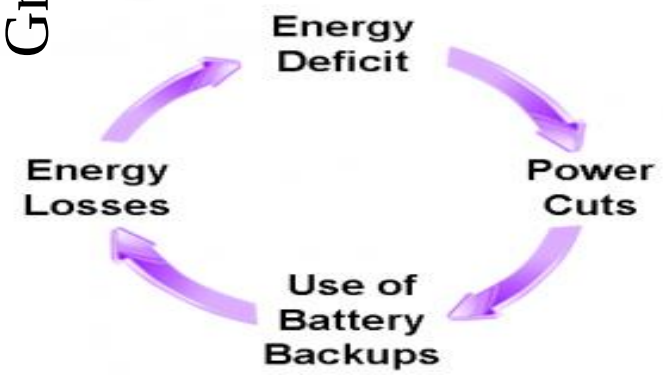
Consumer

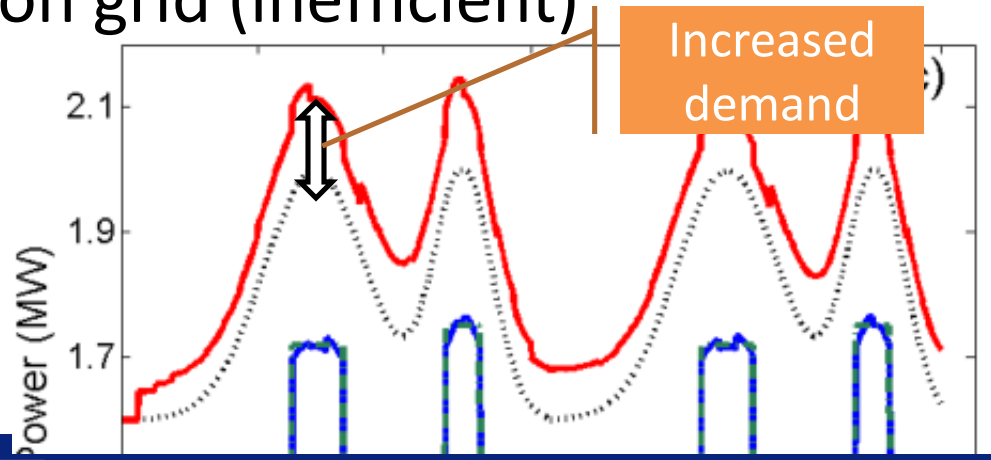
- Cost (initial $300, recurring $100*)
- Limited capacity

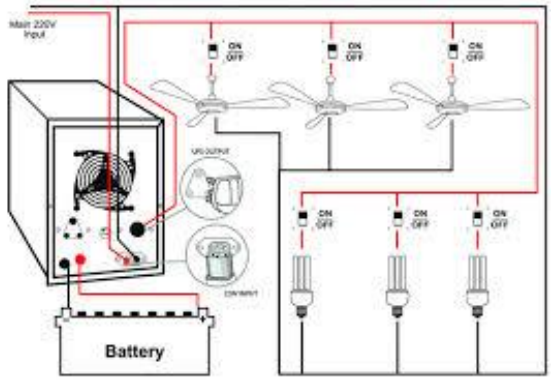
- Rigid selection of appliances (hard-wired)

Grid/Govt

- Increased total load on grid (inefficient)





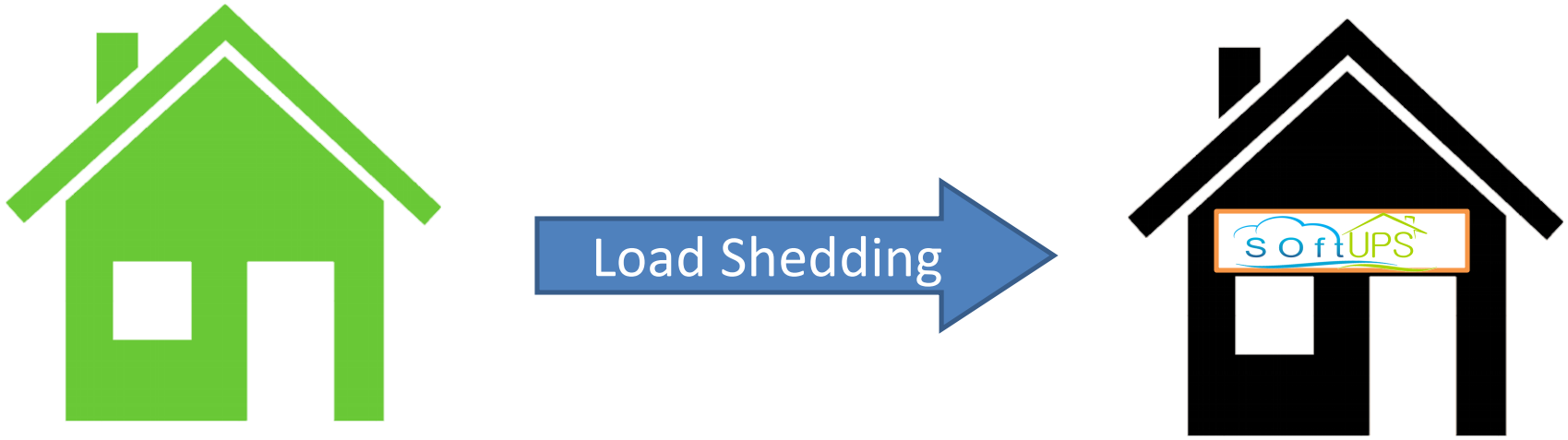


Src: askmohsin.com

"Hidden Costs of Power Cuts and Battery Backups" in **e-Energy'13, May 21–24, 2013**

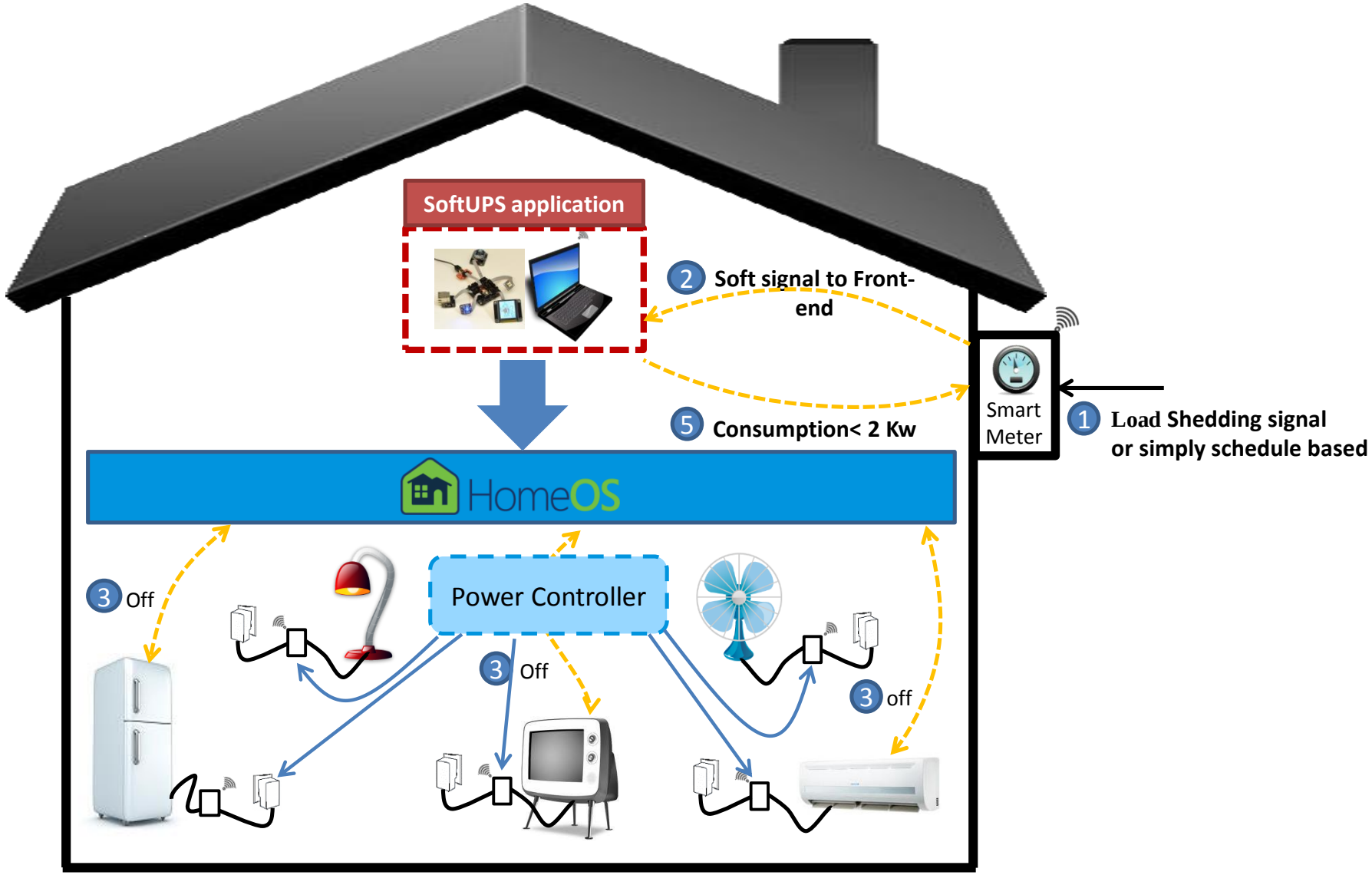
Key Idea for SoftUPS

- 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!



Zohaib Sharani, Khushboo Qayyum, Noman Bashir, Affan A. Syed. **"SoftUPS: Eliminating the need and cost of battery backups in the developing world"**, ACM e-Energy conference, 2014, Cambridge, UK

SoftUPS: Architectural Overview using HomeOS/LoT



Benefits of SoftUPS

- One time cost
- No efficiency losses
- No resource exhaustion

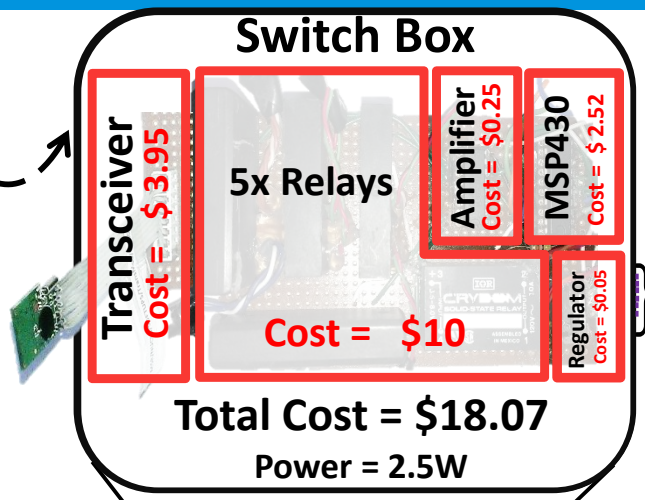
- Dynamic reallocation of power budget

Bonus: implement cost-saving and green policies within home

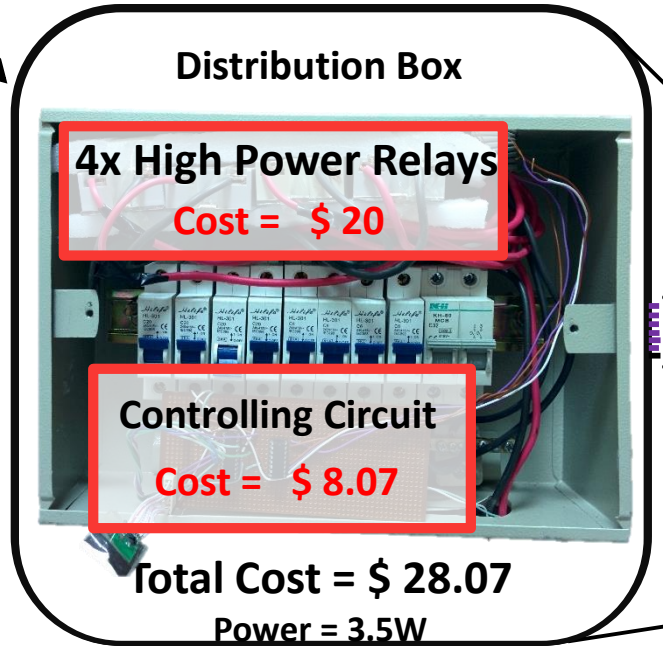
Challenges

- **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



Appliances in the Room



Load Shedding Signal

Smart Meter

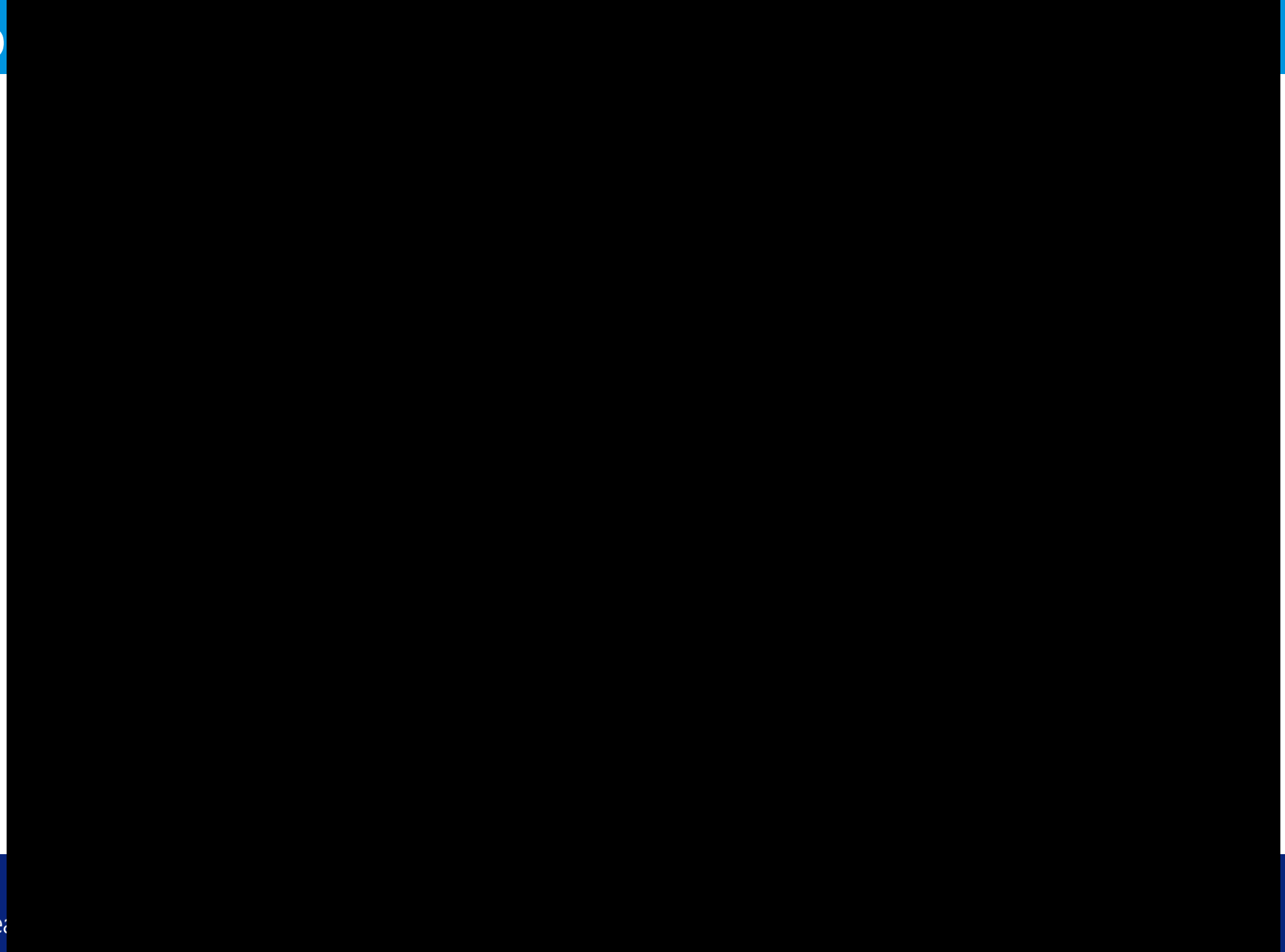
Rooms and High Power Appliances

Main Distribution Board

A demo video

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

A demo



Research Enabled: The road ahead

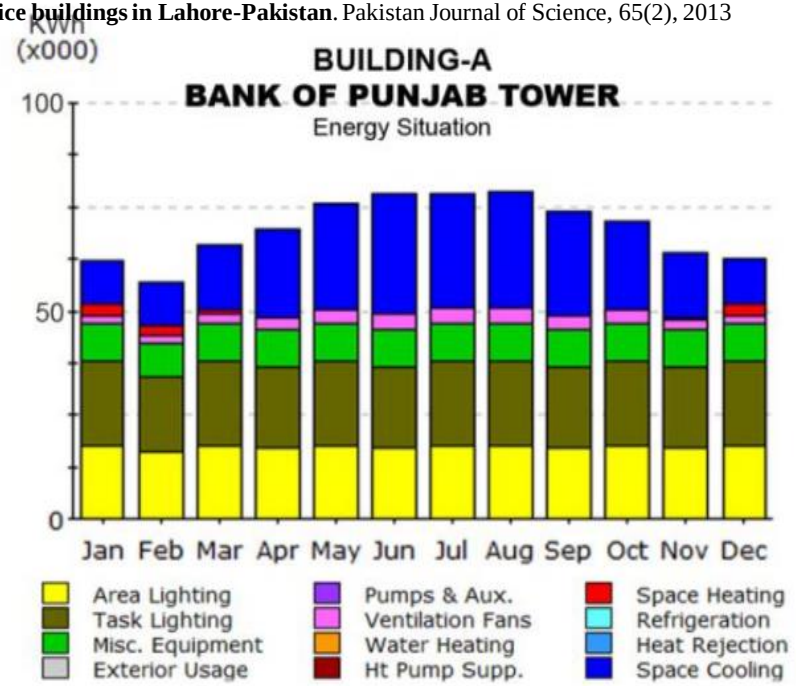
- Power "*congestion control*" algorithms with an automated demand control implemented at home
  - Fully distributed, coordinated, peer-based etc
- Optimal load shedding schedules
  - With different penetration of SoftUPS vs traditional UPS

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

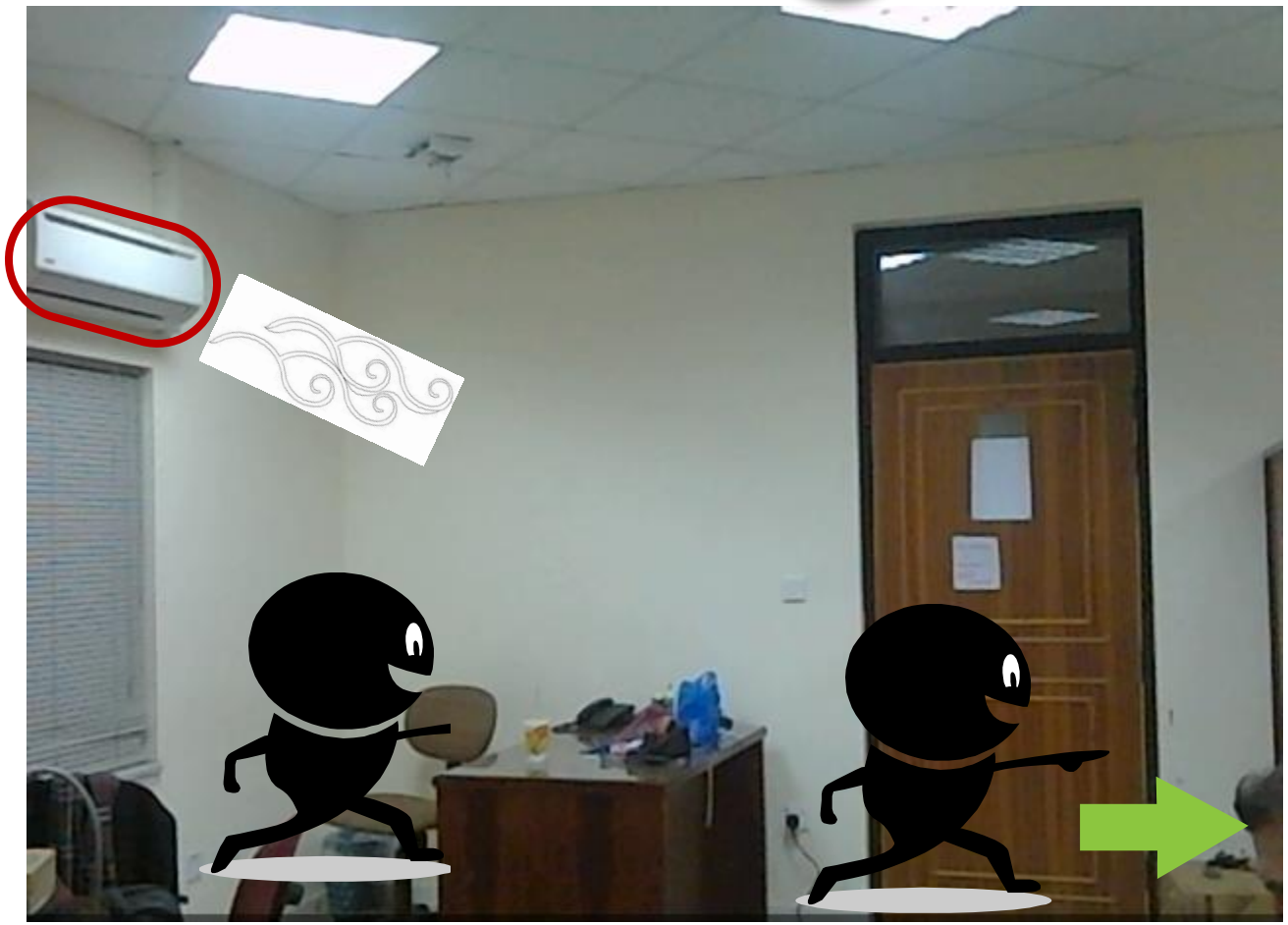


http://www.wahid-industries.com/

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

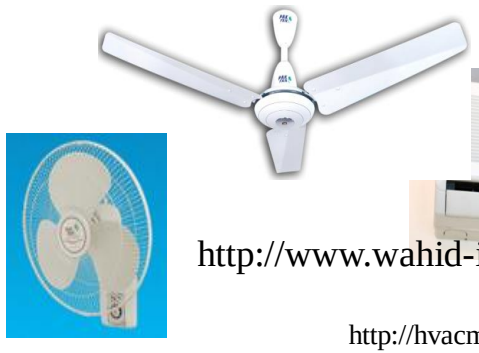
Temp set point = 18°C

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.wahid-industries.com/

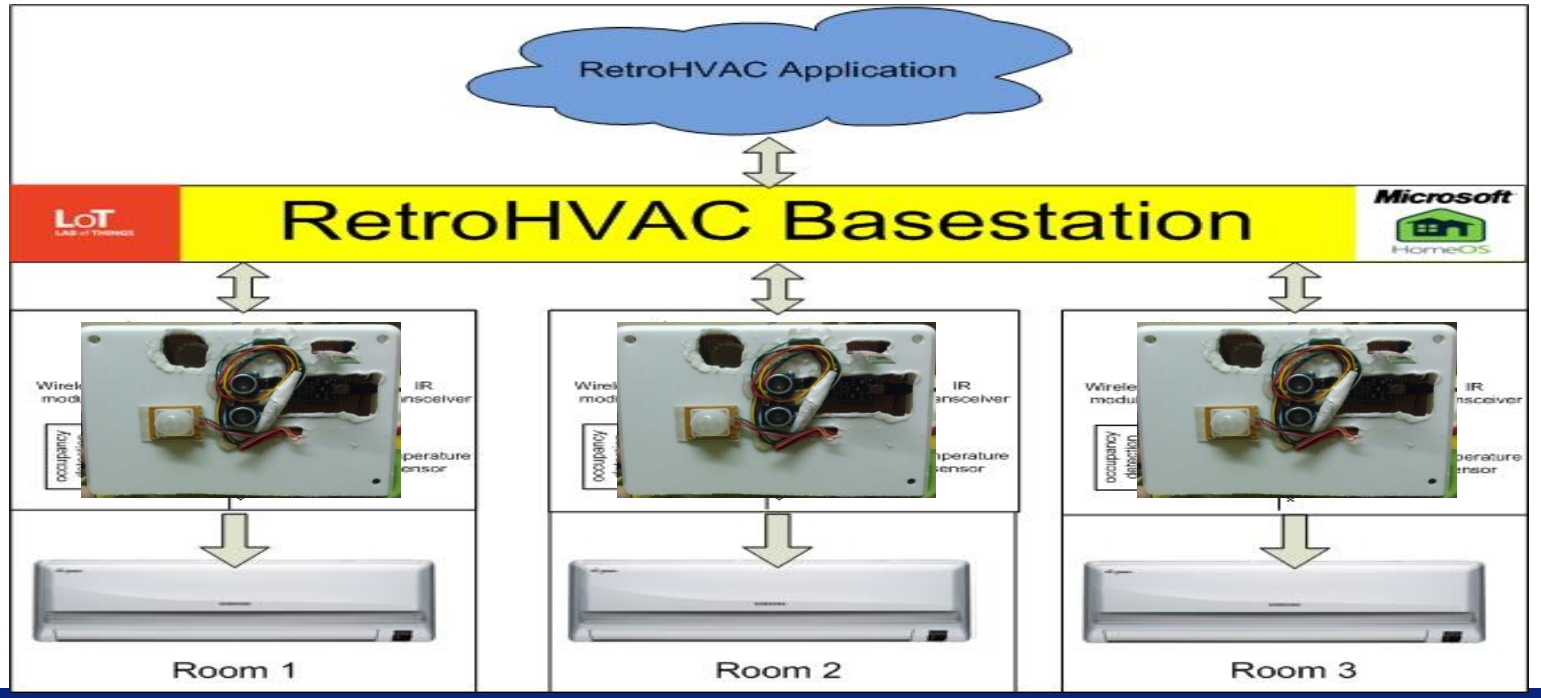
http://hvacmariettaco.com/ductless-mini-split-air-conditioning-systems.html/

http://www.homeadvisor.com/rated.M
rehouseImprovements.133377

http://yashenterprises.apnaghar.co.in/services.aspx

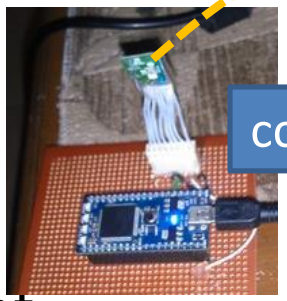
Retrofit elements for centralized control

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

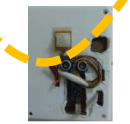


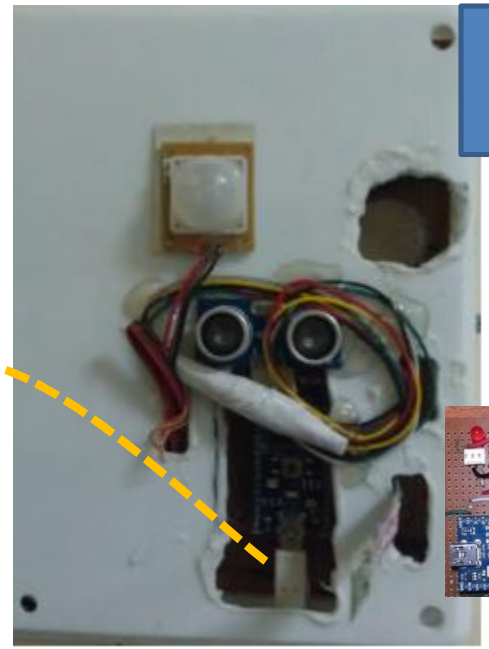
Architecture and Implementation Overview

- Three components of RetroHVAC
  - Control nodes
    - Occupancy and temp detection
    - Actuation of AC
    - Communication
  - Base station
  - Application
    - Policy enforcement

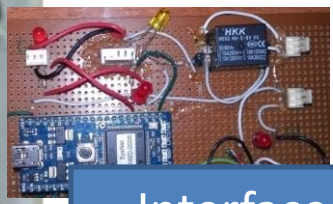


cc2500

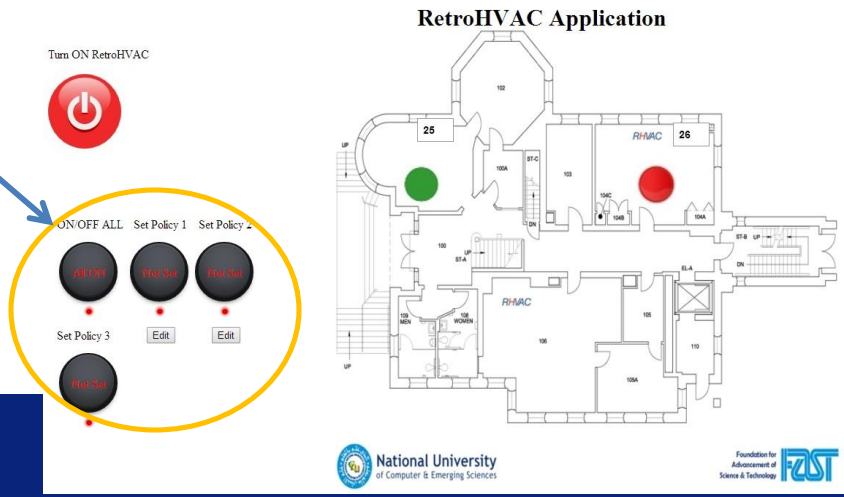




PIR, light, ultrasound, and temp sensors



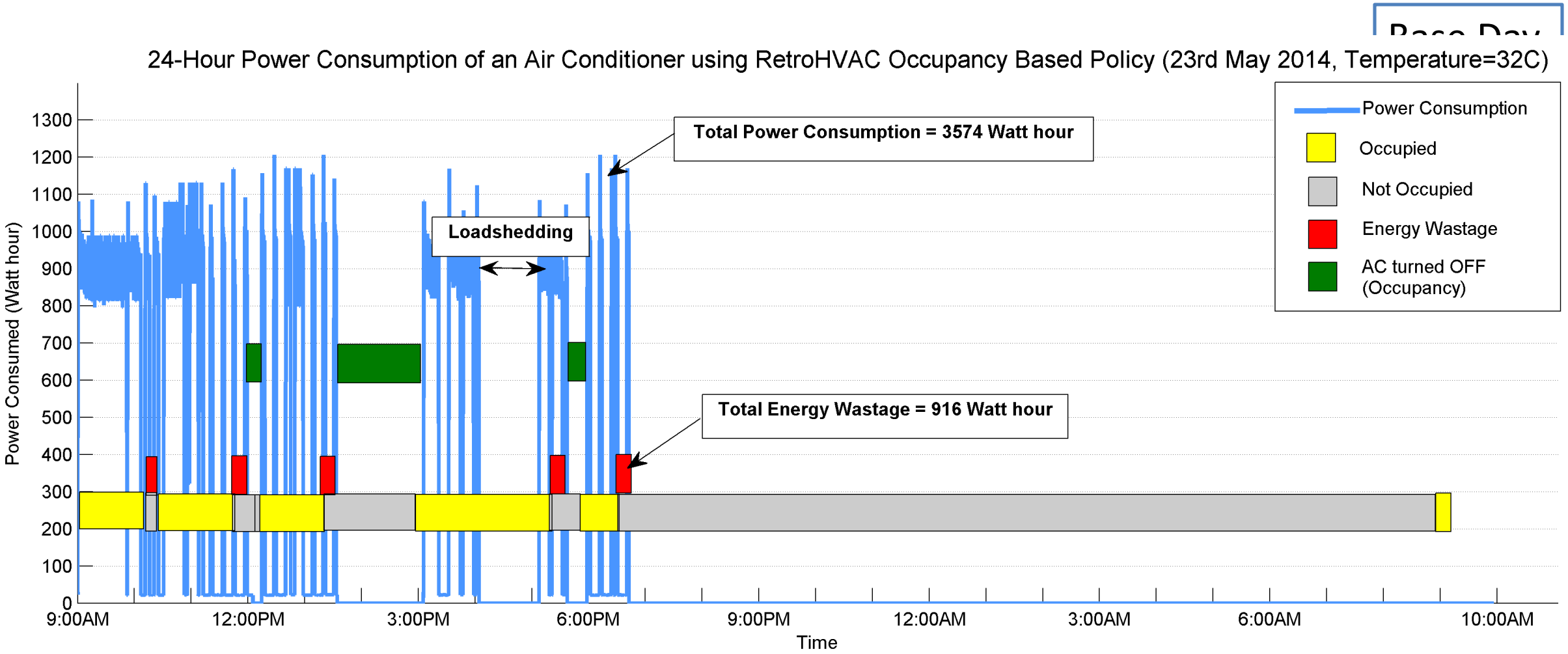
Interface with remote



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



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

What are the wider implication 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