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

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Computer Science

SDN for ISP

Sigcomm CCR

Botnets


Distributed Systems

* = poster or demo

Electrical Engineering

*e-Energy

Underwater networks

WUWNet

Energy harvesting and transference

Smart-home & Smart-Grid


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Microsoft Research

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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/


The Role of Connectivity in Reshaping the World

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

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

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**Load Shedding to Continue Across Maharashtra**


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

<table>
<thead>
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<th>Wed, 02 Jul</th>
<th>Thu, 03 Jul</th>
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Do not hallucinate.
Last summer (2013) it got really bad in Pakistan!

Domestic/Residential sector largest consumer

Src: POWER SYSTEM STATISTICS, NTDC 2012
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

- Cost (initial $300, recurring $100*)
- Limited capacity
- Rigid selection of appliances (hard-wired)
- Increased total load on grid (inefficient)

Increased demand
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

1. Load Shedding signal or simply schedule based

2. Soft signal to Front-end

3. Off

4. Power Controller

5. Consumption < 2 Kw

SoftUPS application

HomeOS

Smart Meter
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
Rooms and High Power Appliances

Load Shedding Signal

4x High Power Relays
Cost = $20

Controlling Circuit
Cost = $8.07

Total Cost = $28.07
Power = 3.5W

Switch Box
5x Relays
Cost = $10

Transceiver
Cost = $3.95

Amplifier
Cost = $1.23

MSP430
Cost = $2.52

Regulator
Cost = $0.05

Transceiver
Cost = $3.95

Total Cost = $18.07
Power = 2.5W
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)

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
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
Three components of RetroHVAC

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

PIR, light, ultrasound, and temp sensors

Interface with remote cc2500
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

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

- **Total Power Consumption = 3574 Watt hour**
- **Total Energy Wastage = 916 Watt hour**

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

Questions