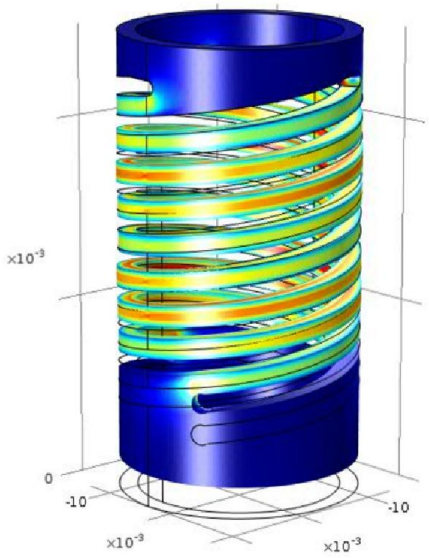

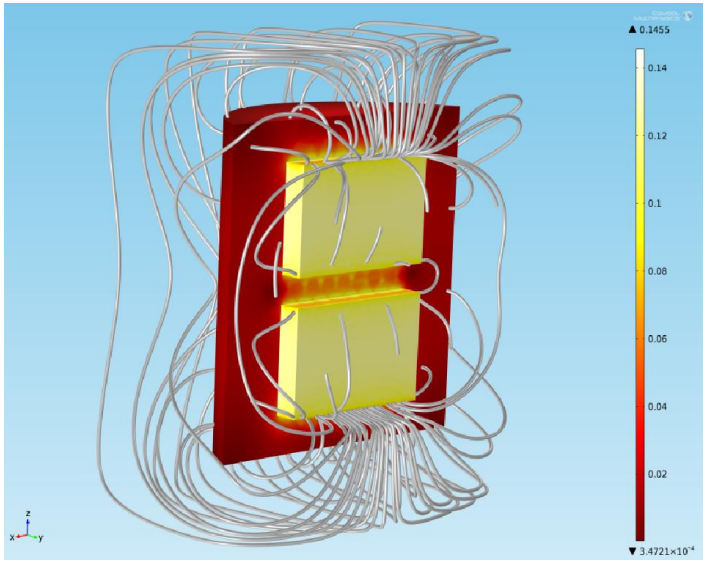

Vibration Energy Harvesting to Enable Wide Scale Deployment of WSN within IoT

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Presented at GreenTouch EUSEW June 2014

HOW THE WORLD IS CHANGING

Mobile data traffic 80% growth

Tablets 50% growth

VIDEO

- YouTube/Netflix/Amazon/Hulu
- UltraHD (4k, 8k)

GAMING

- Sony (Gaikai) / OnLive/ Twitch.TV

CLOUD

- Emerging services (health, education)

IoT

- Digitally connected world
- Smarts in the cloud

Unknown

- How do you sustainably and economically power Billions of sensors??

TelecomMonthly

HOW DO YOU SUSTAINABLY POWER BILLIONS OF DEVICES

ENERGY EFFICIENT WIRELESS SENSOR NETWORKS ARE KEY

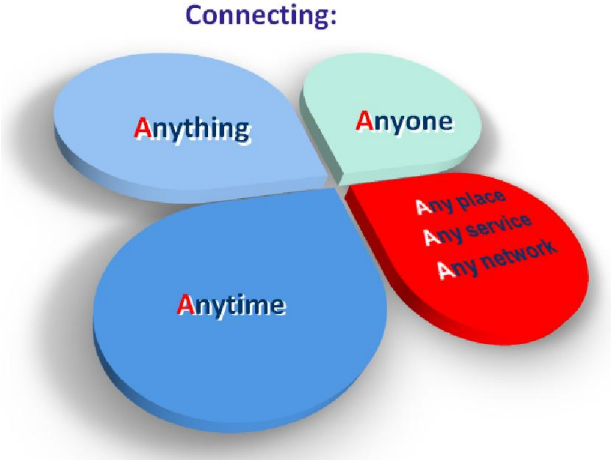
WSN required for:

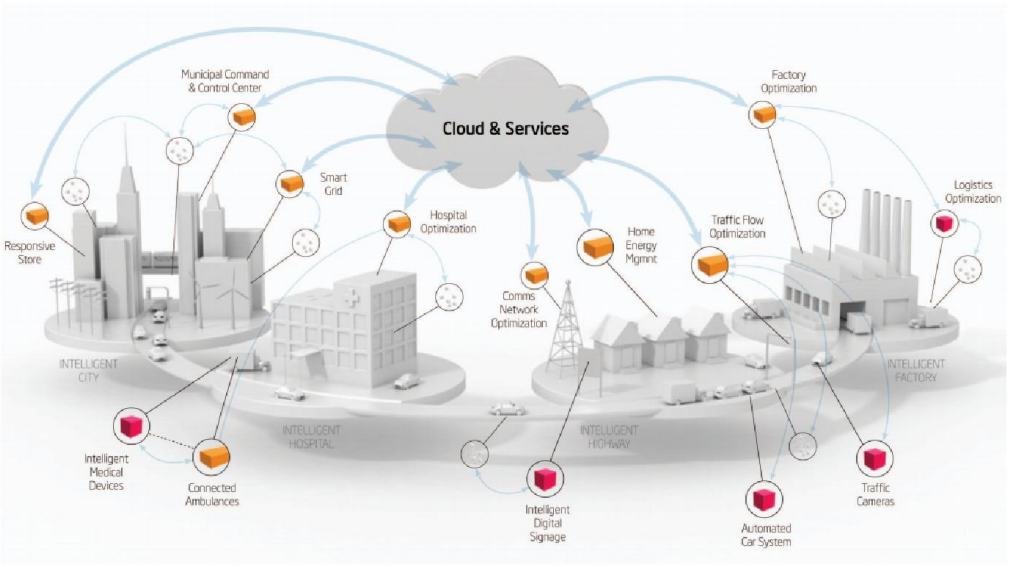
- "Smart" ....buildings, factories and homes
- IoT

Why don't you see WSN deployed everywhere today?

Powering devices is a challenge:

- Even low power sensors measuring 3 simple parameters once every 15 minutes depletes battery in 3-4 months
- Battery replacement costs (CapEx and OpEx) kill the business case
- Battery replacements harm the environment
- Many possible solutions exist but few have real world potential at small scales





SATIZ

POWERING >>SENSORS IS TECHNICALLY & ECONOMICALLY CHALLENGING

ENERGY HARVESTING IS THE KEY

Energy harvesting:

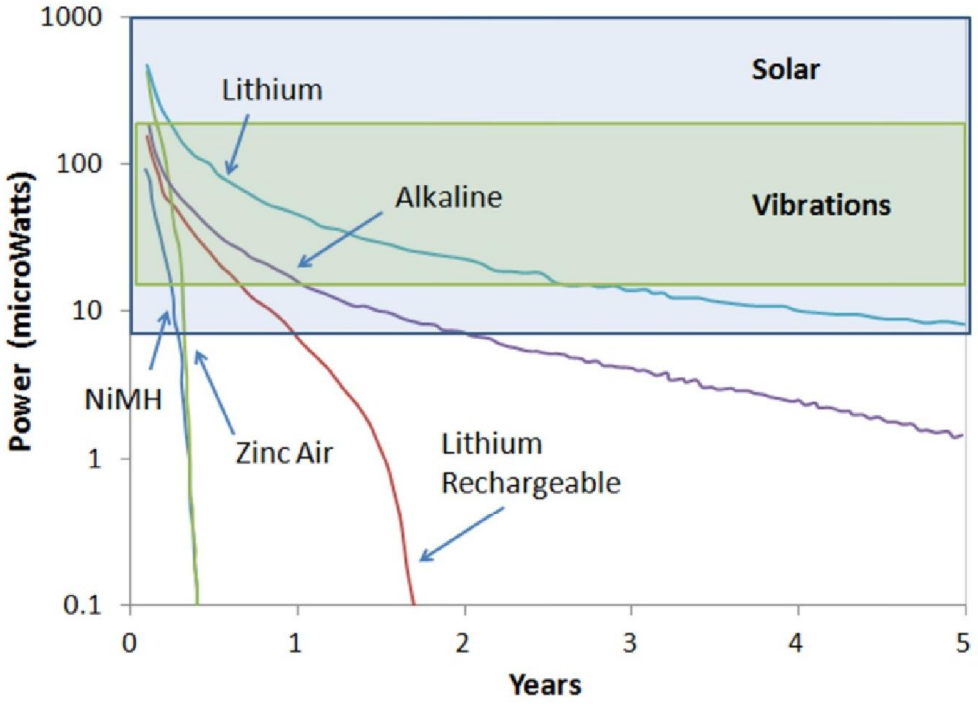
- Many different types
- Solar, vibrations, wind, thermal, RF etc
- Many possible solutions exist but few have real world potential at small scales

Deployed SoA:

- Large and expensive PV with limited deployment configurations
- Large and expensive vibration

Bell Labs approach:

- Targeting improvements in vibration energy harvesting
- Vibrations occur everywhere but efficiently converting to useful energy is difficult
- Bell Labs invented novel mechanical to electrical harvester that can perform at low cost in low physical volume



Roundy et al. (2003)

VIBRATION ENERGY HARVESTING SHOWS PROMISE

BELL LABS VIBRATION ENERGY HARVESTER

How is our approach different:

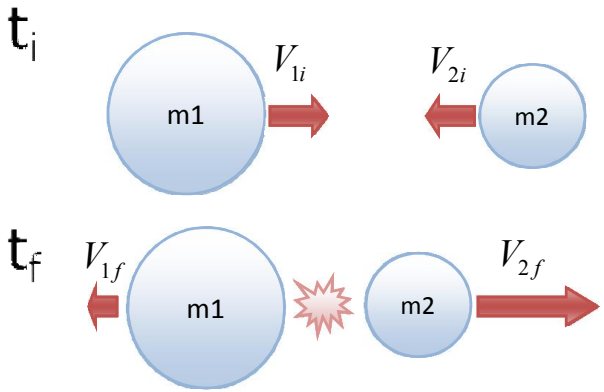
- Traditional vibration energy harvesters employ 1 mass (1 doF)

- The mass is a magnet that moves within a coil to produce electricity

- 1 dof limits the maximum power output and the frequency response of the system

- Note that the power recovered is proportional to the velocity of the mass through the coil squared

$$P \sim V^2$$



$$V_{2f} = \frac{(C_R + 1)m_2 V_{1i} + (m_2 - C_R m_1)V_{2i}}{m_1 + m_2}$$

for $m_1 >> m_2 \rightarrow V_{2f} \approx 3V_{1i}$

Bell Labs approach:

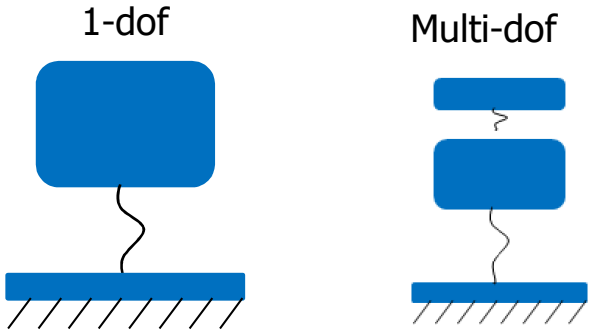
- Employ the velocity amplification principle with multiple masses (multi-dof)

- Conservation of momentum from large to small masses

- Smallest mass has significantly amplified velocity and therefore generates more power

- Multiple masses broaden the frequency response for real world applications

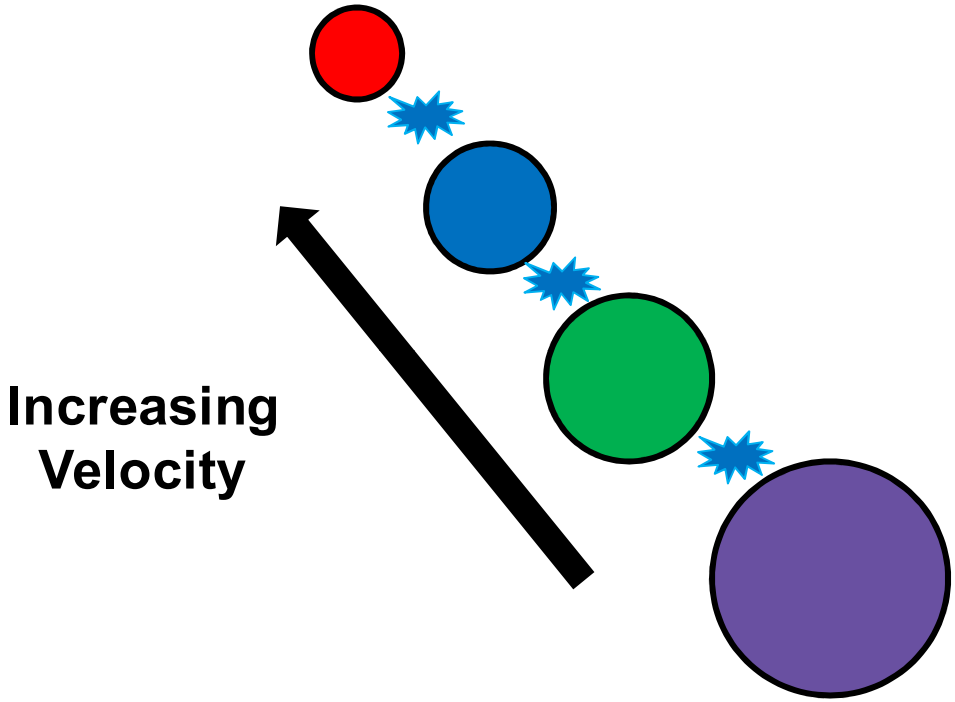
- Simple mechanical design



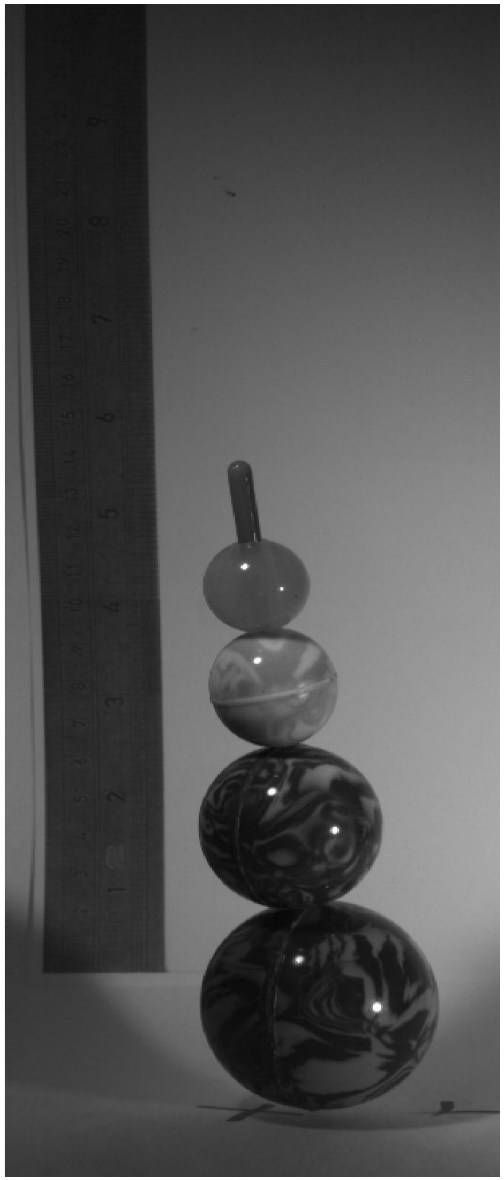
Commercially available approach

Bell Labs approach

BELL LABS VIBRATION ENERGY HARVESTER

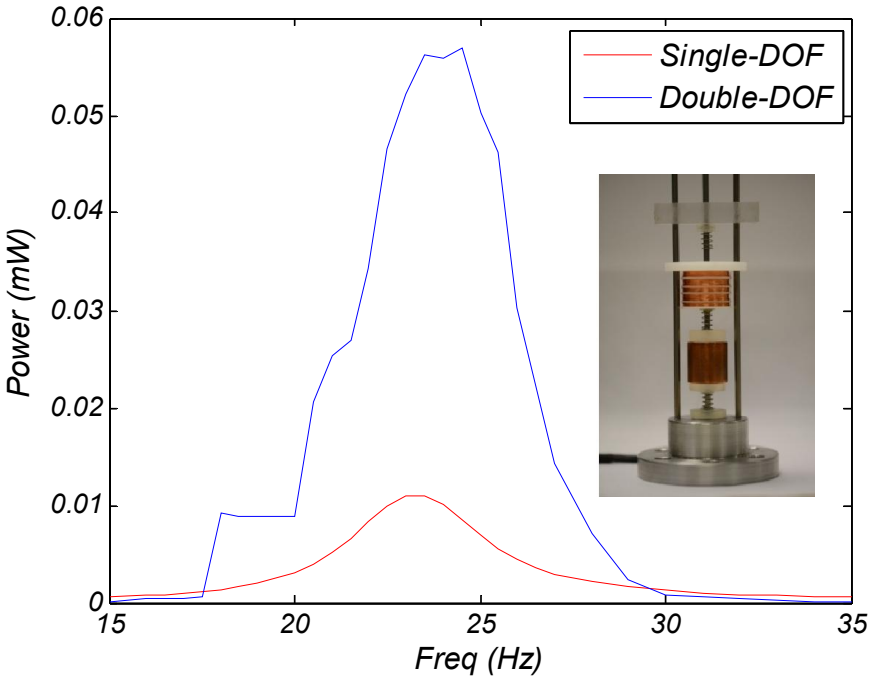


$P \sim V^2$

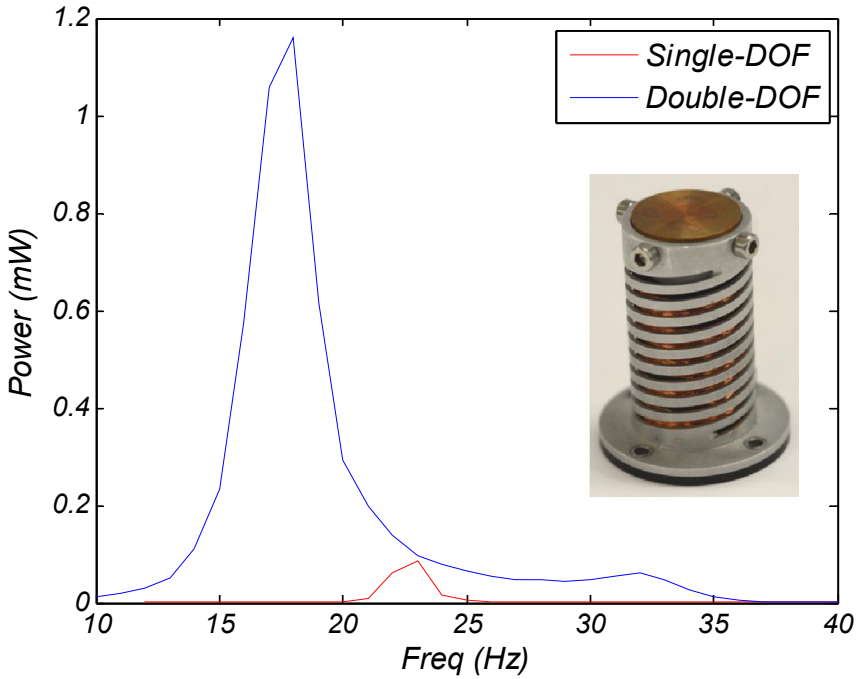


BELL LABS VIBRATION ENERGY HARVESTER

Experimental Results - Compare 1-dof v Multi-dof



Prototype 1: **6X** peak power increase



Prototype 2: >**9X** peak power increase

CONCLUSIONS AND NEXT STEPS

Conclusions:

- Powering Billions of devices in a sustainable, scalable and economically viable way represents a major obstacle to the large scale deployment of WSN within IoT

- Harvesting energy from the environment shows potential but many challenges exist

- We need improvements in low power electronics, high energy density batteries and improvements in energy harvesting

- Bell Labs developed a novel multi mass vibration energy harvester that employs velocity amplification within an electromagnetic system that can produce more than 9X power compared to the traditional approach

Next steps:

- Further optimisation and miniaturisation to AA battery format

- Commercialisation

Thank you

Discussion?