# Networking Challenges for 4G Wireless

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# Drivers for Networking Research: Industry Trends

## Yesterday

- Voice traffic dominant
- Data overlaid on voice networks using modems

## Today

- Data exceeds voice traffic
  - New networks focused on best-effort data traffic
  - Voice overlaid on data (VoIP)
- Internet traffic doubling every year
- Cellular networks hierarchical; very complex because of specialized radio access networks

## Tomorrow

- Content -- primarily video -- will become the dominant type of network traffic
  - Networks will be optimized for content traffic
  - Growth rate of Internet traffic will increase due to content transport
- Cellular networks will be greatly simplified and will also have to be geared for fast content distribution
- M2M communication & new services based on it begin to emerge

# Drivers for Networking Research: Technical Challenges

## Create content-optimized networks to handle explosive traffic growth and inexpensively carry dominant video streams alongside voice, web traffic

- Integrate transmission, switching and storage elements to build scalable and user-centric video and content distribution networks
- Scalability to multi-terabit rates to carry ever increasing video traffic at low cost per bit

## Simplify wireless networks

- Adopt Internet's flat architecture – decomplexify or hide network complexity
- Integrate cellular networks into the global Internet
- Develop flexible (cognitive) radio technologies
- Develop flexible, robust, autonomic network functionality to enable alternative network topologies, deployment methodologies and operations paradigms

# Drivers for Networking Research: Technical Challenges (cont'd)

## Create a flexible way to add new network services and achieve plug-and-play combinations of services

- One operator surveyed needs to create 42 service combinations and a number of new network services (specialized VPN, security services, etc.) just to support its enterprise offers
- Use network virtualization for meeting widely varying needs of different customer using a common underlying network.

## Provide solutions for OPEX reduction as the networks complexity increases significantly with the introduction of new services, applications, as well as convergence

- New mechanisms and hooks to network management systems
- Quicker configuration, easier detection, diagnostics, upgrades and management
- Diagnostic and troubleshooting aids to improve availability of new services

# a little more on Simplying Wireless Networks…

- **Key Challenges**
  - Truly converge cellular and IP networking – hiding complexity. Greater efficiency in managing access technologies is achieved if:
    - Functions that can be shared across access types are shared in the wireless packet core (authentication, lawful intercept, charging, idle-mode mobility, etc)
    - Functions that are really access-specific are part of the base-station

    *Current 4G standards have partly taken a step in this direction*

  - Key cellular functional requirements are still absent in IP technologies. Greater commonality and reuse may be achieved if we:

    (i) extend IP-based protocols with missing cellular functions, and

    (ii) evolve cellular networks to take advantage of the improved IP capabilities (ex: mobility, paging, etc)

    *Until this happens, cellular standards will continue to develop their own (unique) solutions as they need them*

# a little more on Simplying Wireless Networks…

- **Key Challenges**
  - Autonomics - Today's networks require extensive involvement of human operators to plan, configure and manage, operate, maintain and tune networked systems.
  - Even greater effort will be needed as networks scale
  - Autonomics provide a natural paradigm for hiding complexity and enabling technology solutions currently opex-blocked (eg femtocells) – while a nice-to-have in present macro networks given current market economics, autonomic functionality becomes a necessity looking to the future. Femtocells are a first example … small cell topologies will follow (neighborhood cells, hot-spots, etc)

Autonomics example:

# Femtocell auto-configuration & self-optimization

*How do we manage interference in the femtocell-macrocell environment?*

**What we need to cope with is**:

People randomly walking past the house

**ie External mobility**

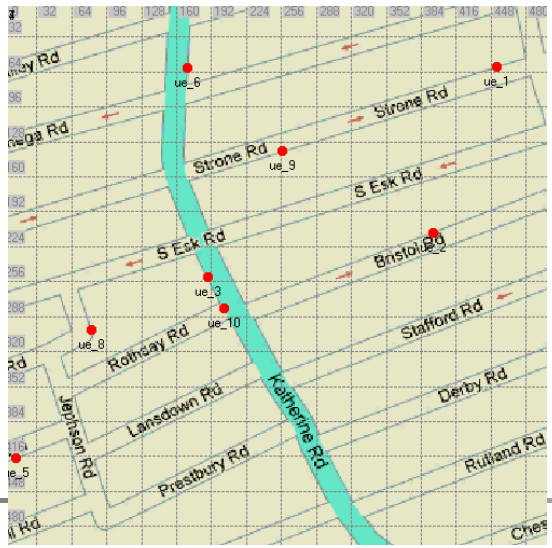
People using the femto inside house

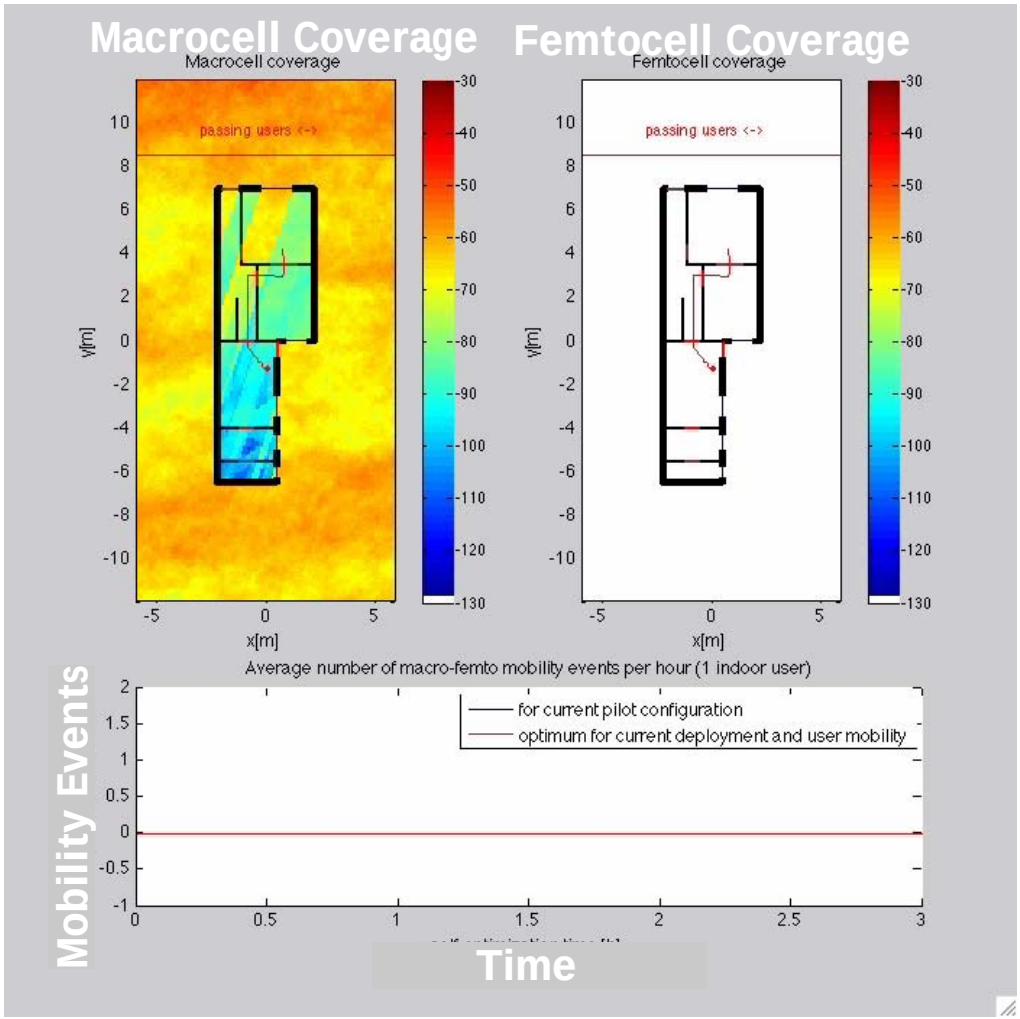
**ie Internal mobility**

**What we should see is:**

A maximisation of the coverage indoors

An optimization of the coverage due to load and location minimizing handover events



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Autonomics example:

# The need to *dynamically* optimizing femtocells

Here's a look at femtocell ←→ macrocell interactions in reuse 1 deployments:

| | Handover probability / Macrocell call | Call Drop Probability due to femto<->macro handovers | Femto<->Macro location updates per hour per macrocell-user |
|---|---|---|---|
| Fixed (BE) Power Setting | ~73.8 % | ~2.92 % | 57.8 |
| Plug-and-Play Power Settings | ~20.4 % | ~0.8 % | **10X Improvement** |
| **Dynamically Self-Optimized Power Settings** | **~7 %** | **~0.27 %** | **8.73** |

- Wisely setting femtocell power will control femtocell ←→ macrocell interactions and reduce network signalling load,
  ie choose the *right* power for each femtocell;
  choose it *automatically*
  choose it often…the *best* femtocell power will not be static!
- Dynamically adjusting power based on demand, load, etc gives ~10x reduction in femtocell ←→ macrocell events

*Autonomics can enable reuse-1 femtocell deployments*

# Conclusions

- We must continue to transform the internet to inherently support mobile users – need to understand the economic advantages of making mobility a first-class citizen in IP

- Cellular networks must be optimized for content delivery to mobile users. When the user takes their session mobile, mobility interactions between the user and the network should not degrade the end-user experience.

- Autonomic network functionality, both in the radio and network domains must be extensively developed to continue to drive operating expenses down and provide greater flexibility in deployment options to improve coverage and end-user throughput.