Workshop on Evolution and Impact of Mobile Data Traffic Off-loading

J. Scott Marcus, WIK-Consult, Project Manager
John Burns, Aegis Systems, Deputy Project Manager
Brussels, 3 September 2013

Background to the Study

- Objectives of the project
- How much off-load is taking place?
- Approaches to traffic off-load
- Implications for future spectrum demand
- Socio-economic benefits

General objectives of the project

- "The objective of the Study is … to perform a socio-economic assessment of recent technical developments, including small cells (like femto- or picocells) in cellular networks that will significantly affect spectrum demand and the efficient use of spectrum for wireless broadband and have an impact on access and backhaul networks including fixed networks."

- Data traffic off-loading is defined for purposes of this study as "routing wireless data that could be served by macro cellular networks (UMTS, LTE or WiMAX) over alternative access network technologies that use local coverage (shorter transmission ranges) and operate in frequencies that may or may not be exclusively accessible by the network operator."

wik CONSULT

ÆGIS systems limited

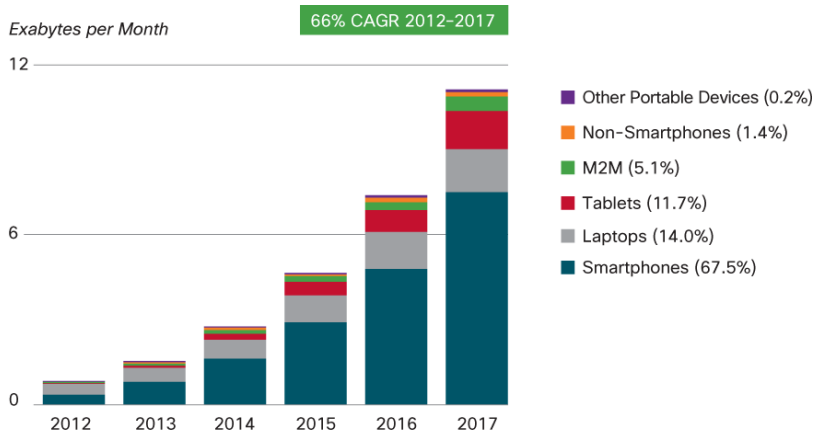
How much off-load is taking place?

- A changing mix of devices
- Changing characteristics of use
- A changing mix of applications
- A rapidly evolving story
- Our estimates

wik CONSULT

ÆGIS systems limited

A changing mix of devices

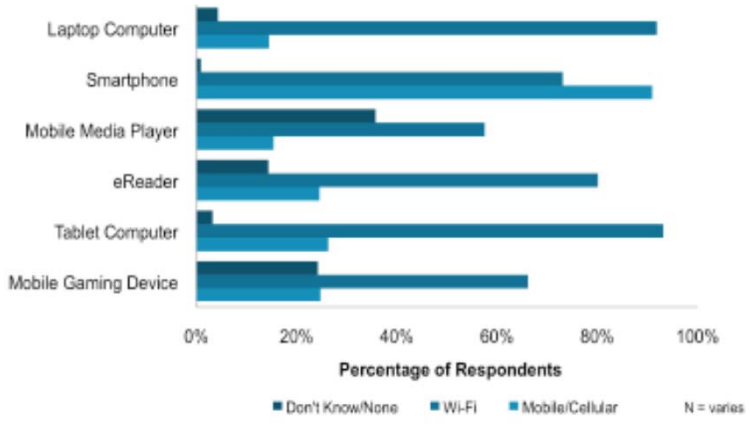


Figures in legend refer to traffic share in 2017.

Source: Cisco VNI Mobile Forecast, 2013

wik CONSULT

A changing mix of devices



Q10. Please describe the wireless capabilities of each of the following devices that you own.

wik CONSULT

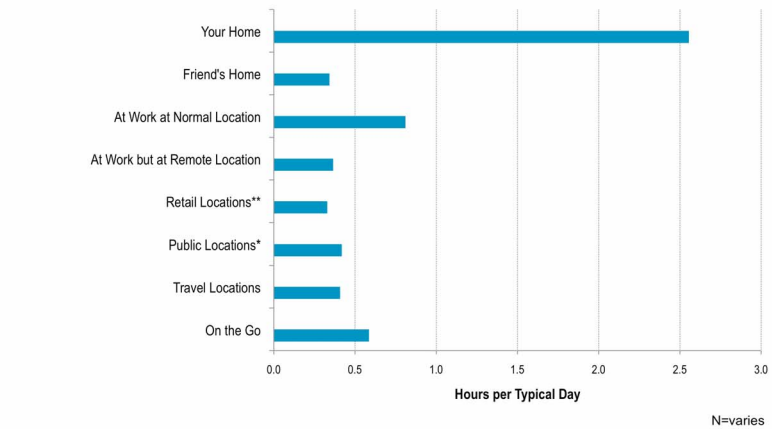
Source: Cisco IBSG (2012)

A changing mix of devices

Wi-Fi Household Penetration %	2011
South Korea	80.3%
United Kingdom	73.3%
Germany	71.7%
France	71.6%
Japan	68.4%
Canada	67.8%
Italy	61.8%
USA	61.0%
Spain	57.1%
Australia	53.8%
Czech Republic	31.6%
Mexico	31.5%
Poland	28.0%
Russia	22.9%
China	21.8%
Brazil	20.4%
India	2.5%

Source: Strategy Analytics (2012)

Changing characteristics of use



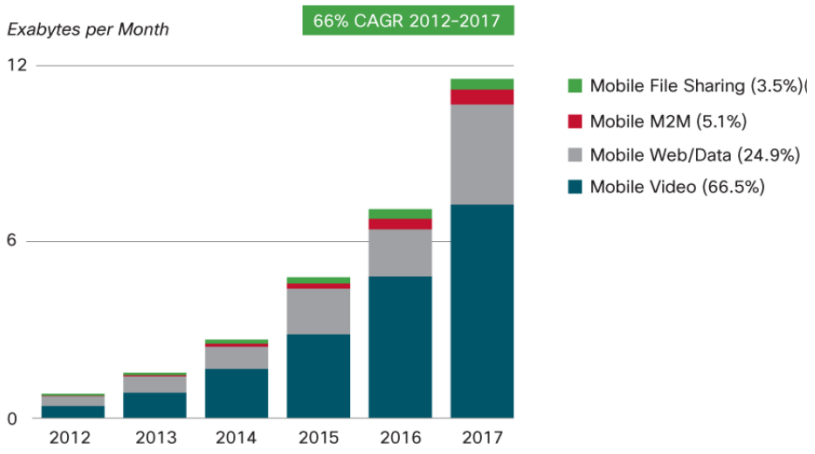
N=varies

Q33. In a typical day, for how long do you use your mobile devices in each of the following locations?

* *Public – e.g., stadiums, parks, schools*
** *Retail – e.g., stores, restaurants*

Source: Cisco IBSG (2012)

A changing mix of applications



Figures in legend refer to traffic share in 2017.

Source: Cisco VNI Mobile Forecast, 2013

A changing mix of applications

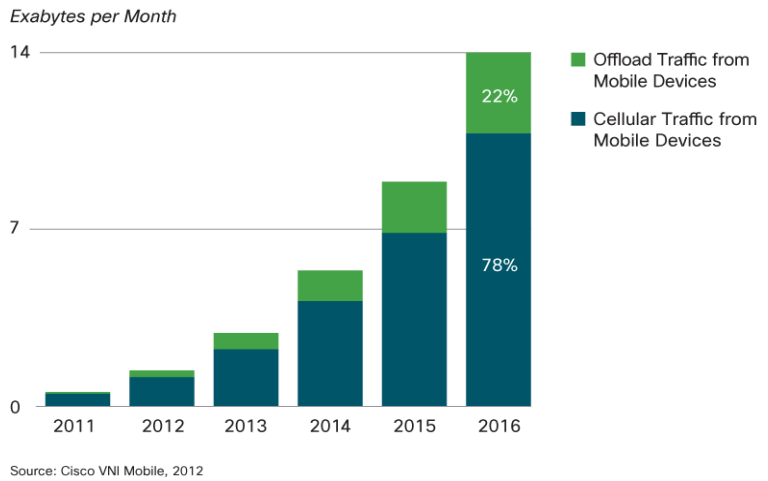
Rank	**Cellular**	**Wi-Fi**	**Roaming**
1	Browsing	Browsing	Browsing
2	Facebook app	YouTube	Facebook app
3	Tethering	Video and audio streaming	Google Maps
4	YouTube	Downloads	E-mail
5	Downloads	iPlayer	Tethering

Source: Informa / Mobidia (2013)

A rapidly evolving story

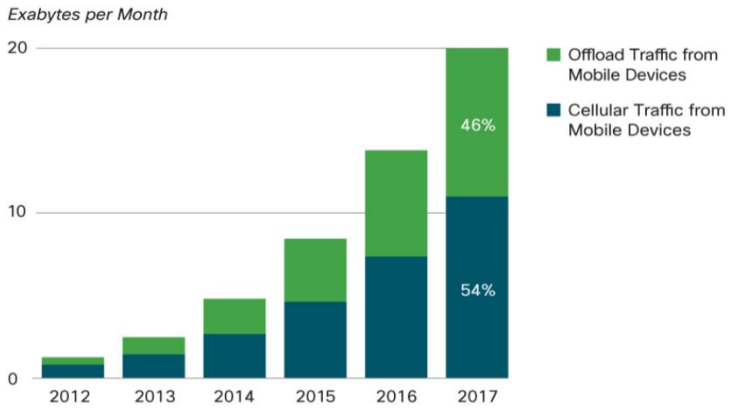
- We had to resolve huge inconsistencies among multiple data sources.
  - Cisco VNI 2012: 11% in 2011, 22% in 2016
  - Cisco VNI 2013: 30% in 2012, 46% in 2017
  - Informa/Mobidia: More than 75% of Android phone originated traffic today in the UK, Germany and France.
- Was the predicted mobile traffic just the tip of a much larger iceberg?

How much mobile off-load is taking place?



Source: Cisco VNI Mobile, 2012

How much mobile off-load is taking place?

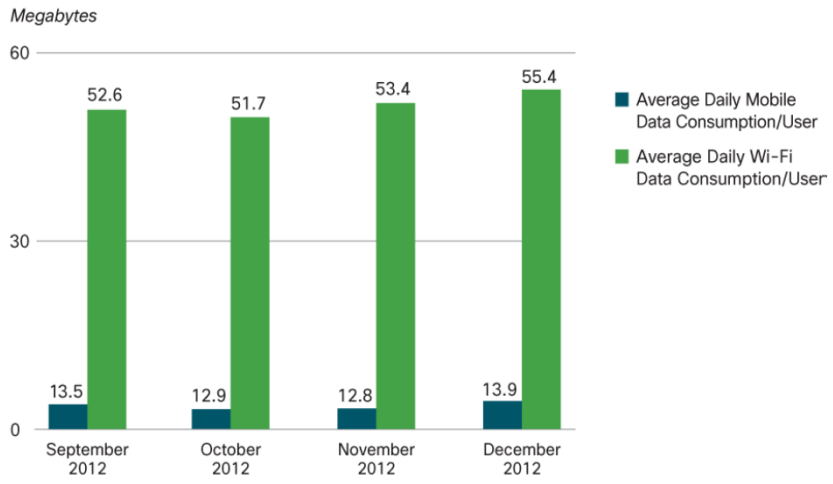


Source: Cisco VNI Mobile Forecast, 2013

How much mobile off-load is taking place?

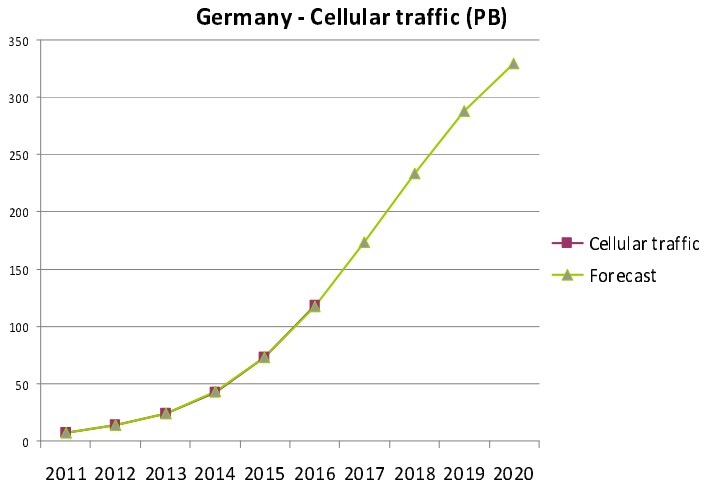
Source: Informa/Mobidia 2013

How much mobile off-load is taking place?



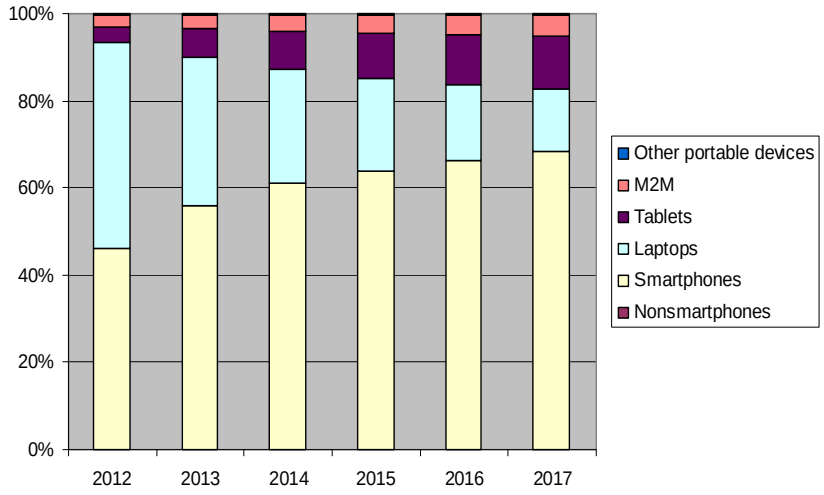
Source: Cisco Data Meter (in Cisco Mobile VNI (2013))

Estimating the volume of data off-load traffic



Data Sources: Cisco VNI (2012), WIK calculations

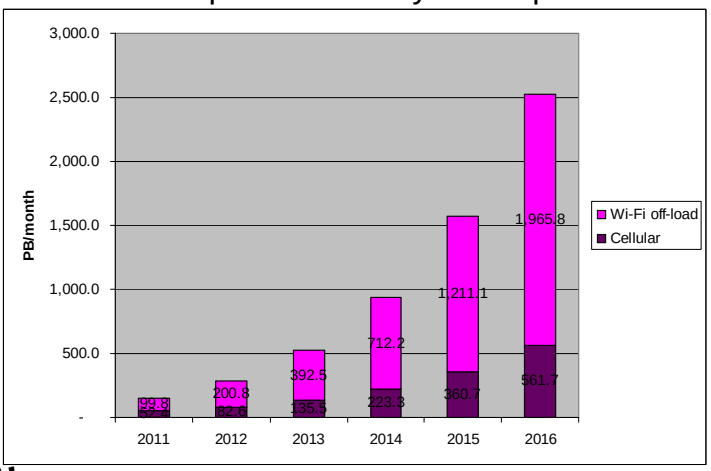
Estimating the volume of data off-load traffic



Data Sources: Cisco Mobile VNI (2013), WIK calculations

Estimating the volume of data off-load traffic

- This estimate depends on many assumptions!



Data Sources: Cisco VNI (2012), Mobidia/Informa (2013), WIK calculations

The hierarchy of human needs

Source: http://imgur.com/Svw7vt7

Definition of Traffic Offload

- In the study ToR, offload was defined as
  - *"Routing wireless data that could be served by macro cellular networks over alternative access network technologies that use local coverage and operate in frequencies that may or may not be exclusively accessible by the network operator"*
- During the study we refined this further, to reflect key distinguishing characteristics of off-load, namely:
  - *(1) that some aspect, either **spectrum** or **backhaul**, is **not under the MNO's control**; and*
  - *(2) that, in the nature of the end user device, it is reasonable to assume that the **traffic would have been sent over the macro cellular network** if it had not in fact been off-loaded.*

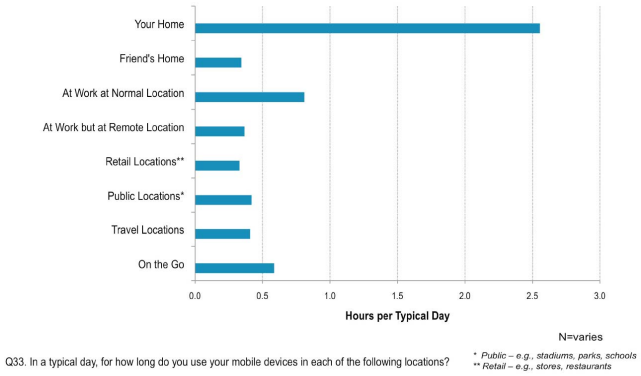
Types of Offload

- Three principal offload scenarios:
  - At home
  - At work
  - In public places
- Two principal offload platforms:
  - Wi-Fi (private or public)
  - Licensed small cells (femto / metro cells)
- Home Wi-Fi currently dominates
  - But public and licensed small cell solutions evolving rapidly

Offload at Home and Work

- Currently most common offload scenario
- Accounts for up to 80% of total mobile data traffic
- Almost exclusively Wi-Fi (even when femtocells present), though enterprise femtocells likely to play bigger role in future
- Relatively simple one-off authentication process, managed by user
- In part reflects device usage profiles

Mobile device usage by location



Source: Cisco IBSG (2012)

Offload in public places

- Wi-Fi hotspots now well established as an offload medium
- Four main approaches to public Wi-Fi delivery:
  - 1. Privately owned hot spots
  - 2. Managed public hotspots
  - 3. Wireless Metropolitan Area Networks (WMANs)
  - 4. Co-operative public Wi-Fi networks.
- Licensed small cells still in infancy but likely to grow significantly in importance as networks evolve

Private hot spots

- Typically used in smaller premises (bars, restaurants, shops etc.)
- Generally use existing backhaul and access points
- Most use simple, password based authentication (or in some cases open networks)
- Larger systems (e.g. hotels) more likely to deploy specialist hardware and software to support traffic management, billing, etc.

Managed hot spots

- Similar principle to private hotspots, but operated by specialist service providers
- Can provide greater user convenience, e.g. automated log in across provider's network
- Can be tailored to meet specific needs of host premises (e.g. bespoke home page)
- May use existing or dedicated backhaul
- Growing rapidly across Europe

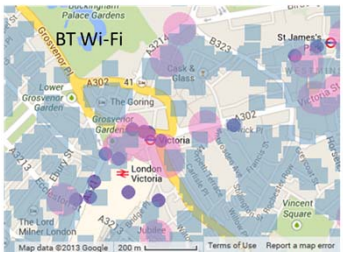
Wireless Metropolitan Area Networks

- Similar to managed hot spots but providing wide area outdoor coverage in high traffic locations
- Need access to suitable backhaul facilities (typically fibre or wireless)
- Mostly operated by established networks but some specialist providers emerging
- Often involve joint initiatives between network operators and local municipalities
- Most interest so far has been in UK

"Co-operative" public Wi-Fi

- Use specially adapted routers to provide public access to private Wi-Fi connections
- Increasingly offered by fixed network operators as value added service
- In Europe, main provider of these services is FON, mostly in collaboration with network operators
- Main benefit is indoor coverage when visiting – outdoor coverage limited compared to WMANs

Public Wi-Fi examples

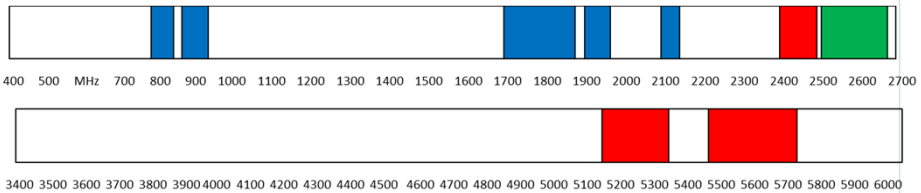


- Managed hotspots
- WMAN coverage
- BT-FON hotspots

wik CONSULT

AEGIS systems limited

Wi-Fi and Cellular Spectrum today



Cellular (suitable for macro use)
Cellular (suitable for small cells)
Wi-Fi

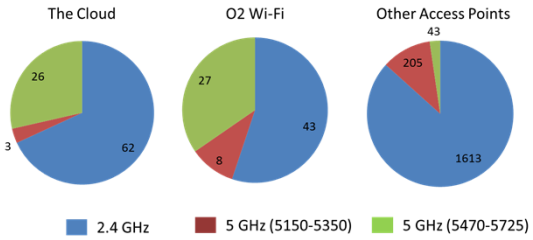
400 MHz
190 MHz
} 590 MHz total
538.5 MHz

wik CONSULT

AEGIS systems limited

Wi-Fi Spectrum Utilisation

- Home use still almost all 2.4 GHz
- Enterprise 5 GHz use growing but mainly still 2.4 GHz
- Managed hotspots and WMANs appear biggest driver of 5 GHz



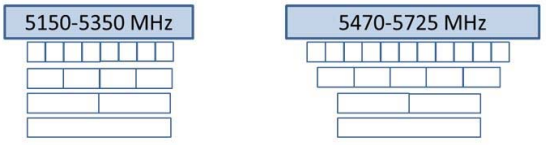
Detected access points, Covent Garden area of central London, Jan 2013

- Expect big growth in 5 GHz use to accommodate emerging higher speed Wi-Fi standards (802.11ac)

wik CONSULT

Limitations of current Wi-Fi spectrum

- 2.4 GHz: only 3 non-overlapping channels and numerous other uses – increasing congestion
- 5 GHz : fragmented and constraints apply to protect incumbent radar users



455 MHz total

19 x 20 MHz = 380 MHz (83% utilisation)
9 x 40 MHz = 360 MHz (79%)
4 x 80 MHz = 320 MHz (70%)
2 x 160 MHz = 320 MHz (70%)

wik CONSULT

Spectrum Demand Expectations

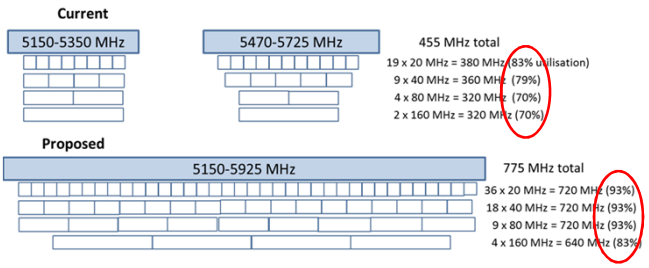
- Wi-Fi
  - Spectrum demand growth mainly driven by residential / enterprise fixed broadband and in-home video distribution, but offload still significant especially outdoors (WMANs)
  - We estimate total spectrum required to support private and public Wi-Fi over long term to be in the range 480 – 640 MHz
- Licensed small cells
  - Existing cellular bands likely to be sufficient for existing networks / services but additional spectrum may be required to support longer term evolution

wik CONSULT

AEGIS systems limited

Anticipated Wi-Fi spectrum needs

- Analysis reveals likely *shortfall* of 60 – 180 MHz
  - Driven mainly by home and enterprise demand
- Latest Wi-Fi standards need wider channels
- Amplifies effect of existing 5 GHz fragmentation
- Optimum solution: extend existing 5 GHz band



wik CONSULT

AEGIS systems limited

Offload Technology Evolution

- Wi-Fi
  - Higher speeds, Improved spectrum efficiency
    - MIMO, Smart antennas / beamforming, channel bonding (802.11ac)
  - Improved ease of access and cellular interworking
    - Authentication (Passpoint™, HS2.0), Automatic Network Discovery (ANDSF)
- Licensed Small Cells
  - Low cost “plug and play” technology for home and business deployment
  - Metrocells combine cellular (3G/LTE) and Wi-Fi
    - Maximises addressable market and amount of accessible spectrum
    - Minimises costs (same backhaul and site infrastructure used for both)

wik CONSULT

ÆGIS systems limited

Offload Market Evolution

- Wi-Fi
  - Market already mature but dominated by private use
  - Increasing interest in “carrier Wi-Fi” for public access
    - Relieves pressure on macro cellular networks
    - Opportunities for fixed operators to extend market reach / increase brand loyalty
    - Both premium Wi-Fi hotspots and community networks (FON) play a role
- Licensed Small Cells
  - Early days but big growth expected
    - Cost effective capacity expansion whilst maintaining customer ownership, network control and quality of service
  - Seen as complementary to Wi-Fi, not a substitute
    - Wi-Fi provides maximum capacity in specific locations
    - LTE small cells offer more predictable QoS in a mobile environment

wik CONSULT

ÆGIS systems limited

Estimating socio-economic benefits

- Human activities tend to have both costs and benefits. Policy interventions also have costs and benefits.
- Socio-economic benefits to consumers, net of all costs, are referred to as consumer welfare (or surplus).
- Analogously, benefits to producers, net of all costs, are referred to as producer welfare.
- Societal welfare is generally taken to be the sum of consumer welfare plus producer welfare. This is what we should seek to maximise.

Estimating socio-economic benefits

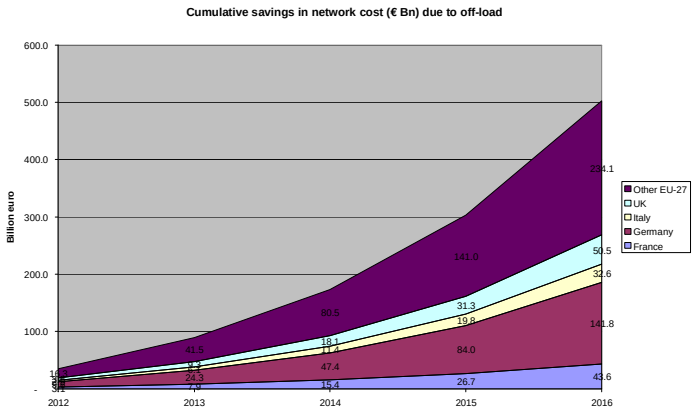
- Benefits are modeled against a hypothetical, counter-factual world where off-load were somehow impossible.
- The dominant benefit by far is cost savings for mobile networks in the real world.
- The analysis necessarily involves many simplifying assumptions.

Estimating socio-economic benefits

- Our estimate represents an upper bound.
- In reality, in the absence of traffic off-load:
  - A portion of the traffic now being off-loaded would be carried over the macro cellular network. This traffic would likely impose (1) substantial additional costs on MNOs, (2) additional usage-based charges for consumers, and (3) congestion on mobile networks with complex implications.
  - A portion of the traffic now being off-loaded would shift to conventional fixed network devices and applications (e.g. personal computers).
  - A portion of the traffic would disappear, because the consumer would not choose to use the network in this way.

Estimating socio-economic benefits

- Our estimate depends on many assumptions.



Traffic off-load and DAE objectives

- Traffic off-load is unlikely to have much impact on the *coverage* of services of up to 30 Mbps.
- It can, however, be expected to generate
  - substantially greater traffic from mobile devices than would otherwise be the case, and also
  - a somewhat greater number of subscriptions than would otherwise be the case.
- Coverage of 30 Mbps broadband services is an explicit DAE objective; adoption is not.
- Nonetheless, increased adoption and usage must be seen in a positive light.

Findings and recommendations

	Helpful	Harmful
Internal Origin	**Strengths** • Increasing speed and capability of devices and services, enhanced price performance (Moore's Law). • Emergence of simplified authentication schemes such as PassPoint. • Progressive deployment of basic and ultra-fast fixed broadband as a back-haul medium.	**Weaknesses** • The risk that licence-exempt spectrum becomes too crowded to support Wi-Fi at sufficient quality. • The risk that basic and ultra-fast fixed broadband does not deploy fully enough. • The risk that administrative arrangements stifle the deployment of service-provider broadband. • The risk that leased line back-haul (or equivalent) is not available at competitive prices, terms and conditions.
External Origin	**Opportunities** • Lower costs for network operators. • Faster and more reliable service, together with lower prices, for consumers.	**Threats** • Risk that the Opportunities are not realised.

Findings and recommendations

- Findings:
  - The 2400 MHz band is crowded.
  - The 5 GHz band is not crowded at present, but will become crowded if rates of traffic growth persist as we project.
  - Fragmentation of the band means that less spectrum is available for the wider bandwidths offered by the latest Wi-Fi technology.

Findings and recommendations

- Recommendation 1. The EU should seek to make licence-exempt spectrum available through as much of the 5 GHz band as feasible. The goal should be to enable Wi-Fi to operate on a non-exclusive basis in a contiguous band from 5150 MHz all the way to 5925 MHz.

Findings and recommendations

- Findings
  - The recently licensed 2.6 GHz band is particularly attractive for small cell deployment, requiring relatively small antennas and a very high degree of spectrum re-use.
  - The 3.5 GHz band, which has been extensively licensed for WiMAX and BWA networks in Europe but to date has been only lightly used, is also well suited to small cell deployment.

Findings and recommendations

- Recommendation 2. The Union should continue to seek to make the 2.6 and 3.5 MHz bands in all Member States available for WAPECS use, thus enabling their flexible use for macro cells, small cells or backhaul as required.

Findings and recommendations

- Recommendation 3. The Commission should initiate a consultation process on the future licensing options for the 3.5 GHz band and other potential new mobile bands, covering options such as national licences, regional licences, spectrum sharing between one or more licensed operators or a registration process for individual small cell base stations.

Findings and recommendations

- Findings:
  - A substantial proportion of Wi-Fi access points are provided by devices with a single radio.
  - If any of the devices using the access point lack 5 GHz capability, the access point will necessarily be forced to operate solely in the (often crowded) 2400 MHz band.
  - Concurrent dual band access points are available at modest additional cost, and are being increasingly deployed especially by public Wi-Fi providers.
  - A large fraction of the installed base, particularly in the residential sector, consists of single radio access points.

Findings and recommendations

- Recommendation 4. The Commission should use its good offices to raise awareness on the part of Wi-Fi equipment providers and the public at large of the benefits of dual radio hotspots.

Findings and recommendations

- Finding: Many forms of off-load depend on consumer adoption of fixed broadband.
- Recommendation 5. The need for fixed broadband as a back-haul medium for traffic off-load provides yet another reason to press ahead with the Digital Agenda for Europe (DAE) objectives to ensure universal availability of basic broadband to all Europeans in 2013, and of ultra-fast 30 Mbps broadband to all Europeans in 2020.

Findings and recommendations

- Findings:
  - For high end service provider off-load, a competitive supply of leased lines (and increasingly of Ethernet-based equivalents) is likely to prove to be essential, particularly as traffic volumes increase over time.
  - Wholesale terminating segments of leased lines are can be regulated ex ante, but Member State NRAs have not been consistent in imposing or enforcing obligations.
  - Recommendations introduced by the European Commission in 2005 concerning charges and provisioning time scales now appear to be outdated.
  - Leased lines are essential to many competitive services, and also to enterprise users.

Findings and recommendations

- Recommendation 6. The Commission and BEREC should endeavour to ensure stronger and more consistent and effective imposition and enforcement of ex ante obligations on the provision of leased lines and Ethernet-based equivalents on incumbents that possess Significant Market Power (SMP) in regard to these critical inputs. In particular, an update of the 2005 Leased Line Recommendations, together with other measures to standardise best practice in leased line regulation across the EU, may be warranted.

Findings and recommendations

- Findings:
  - Small cells tend to be much less intrusive than large ones, but can still raise *NIMBY* (for *Not In My Back Yard*) concerns.
  - Local impediments to the construction of masts can vary greatly from one Member State to the next.
  - Emission standards (EMF) are subject to a general framework; however, a number of Member States implement stricter standards.
  - Municipalities sometimes also impose standards.

Findings and recommendations

- Findings (continued):
  - Administrative barriers are probably less of a problem for a single, individual small cell than for a large cell used by the macro cellular network.
  - Unfortunately, an off-load network requires a huge number of cells.
  - A detailed study of these issues seems to us to be warranted.
  - Reduced impediments should benefit the macro cellular network as well.

Findings and recommendations

- Recommendation 7. The Commission should consider undertaking further studies relating to administrative impediments to the deployments of macrocells and off-load small cells (including Wi-Fi). Any recommendations should pay due consideration to the principle of subsidiarity.

Recommendations

- Recommendation 1. Seek to make spectrum from 5150 MHz to 5925 MHz available globally for Wi-Fi (subject to appropriate sharing mechanisms).
- Recommendation 2. Continue seeking to make 2.6 GHz and 3.5 GHz fully available for mobile use.
- Recommendation 3. Consult on future licensing options for 3.5 GHz and other potential new licensed mobile frequency bands.

Recommendations

- Recommendation 4. Raise awareness of the value of dual radio hotspots (for concurrent 2.4 / 5 GHz operation).
- Recommendation 5. The need for back-haul for traffic off-load provides yet another reason to press ahead with DAE broadband goals.
- Recommendation 6. Ensure effective and consistent imposition and enforcement of remedies on firms that have SMP in regard to leased lines and equivalents.
- Recommendation 7. Consider further studies on administrative impediments to mobile and off-load deployment.