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# ***5G – the future of networking***

## ***A military perspective***

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# *Outline*

- History
  - wireless communication in the old days
  - 1G – 4G
- 5G
- Military scenarios
- Summary



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## *How it all started...*

- Mechanical communication systems
- Charles Wheatstone developed a method to transmit electrical pulses over a metallic cable in 1838
- In 1840, Samuel Morse devised his code
- The first telegraphic Morse code messages were passed in 1844 between Washington and Baltimore
- The electric telegraph rendered mechanical systems useless, however, there were problems...



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# ***Problems in military communication***

- Deficiencies in power supply
  - required frequent retransmissions
- Transmission time up to 24h
- Interference
  - "send reinforcements, I am going to advance"
  - "send three and four pence, I am going to a dance"
- Inflexible system
  - relied on cables



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## *The wireless era*

- James Clerk Maxwell proposed an idea for wireless communication in the 1860s
  - electro-magnetic waves can be propagated in space and travel at the speed of light
- Heinrich Hertz demonstrated electro-magnetic wave propagation over a few metres in 1888
- By the 1890s, practical wireless sets were built
  - Royal Navy officer, Captain H.B. Jackson
  - Italian entrepreneur, Guglielmo Marconi





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# ***The great European naval race***

- Germany vs. Great Britain
- Also civilian maritime trade expanded
- Marconi saw a potential business area
  - communication ship-to-ship and ship-to-shore
- By 1900 the British Admiralty purchased 50 sets of Marconis products
  - 42 for ships and 8 for shore stations from Dover to Scilly Islands
  - range over 50 miles; 10 words/minute
  - explosive growth...



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## *The network of the British Empire*

- British Admiralty requirements were to be able to communicate simultaneously with a large number of ships spread over the worldwide oceanic area
- Building of worldwide chain of shore radio stations
- Intercontinental communications by cable
  - by the end of the 19<sup>th</sup> century the British Empire owned over 60%





# 1G

- From Meri-VHF, MTD, and ARP to...
- NMT (*Nordisk MobilTelefoni*) in 1981
  - NMT 450
  - NMT 900
- Analog
- Range 2-30km







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## 2G

- Digital mobile services
- Circuit switched
- GSM or CDMA
- Enhancements to support data transmissions
  - GPRS
  - EDGE
  - HSCSD

GSM®



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# 3G

- Circuit switched and packet switched
- UMTS, CDMA2000, FOMA (WCDMA)
- Developed to be the follower of 2G
  - video conferencing was seen as the killer application
  - Japanese experience says downloading music is the killer application
- Flop in Europe due to spectrum license fees
- Succeeded in Japan and South Korea
  - these countries have a national infrastructure strategy
- The technology is complex and expensive
  - both for users and operators
- 4G is strongly on its way
  - e.g. India will go directly from 2G to 4G because they consider 3G to be developed but not cost efficient





# 4G

- Packet switched networks
  - the idea is to support IP traffic
- High-speed Internet to the pocket
- Bluetooth (?) (WPAN)
- WiFi (WLAN)
- WiMax (WMAN)
- MBWA (WWAN)





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# 5G ??

- Assumptions
  - High-speed fiber networks
  - High-speed wireless networks
  - IPv6
  - Ubiquitous computing
  - Ad hoc abilities
  - Complete mobility
  - Applications
- The network is everywhere
  - various heterogeneous networks, but considered as one
  - virtual communities on top



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*virtual networks*



*fixed*

*mobile*

*wired*

*wireless*

***Access networks***

***Core network***





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# *Military scenarios*



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# ***The threat environment***

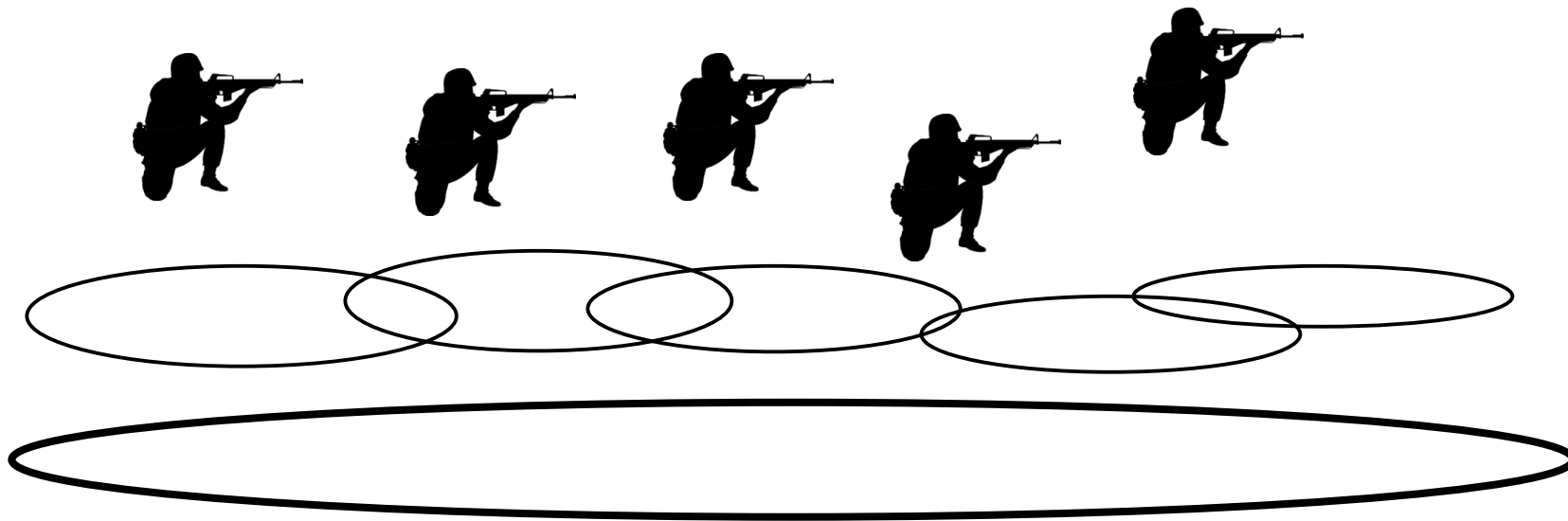
- The threats are global
  - Conflicts, terrorism, warfare (nations and non-nation organizations), organized crime,...
- International operations
  - NATO (Finland is a PfP country)
  - EU
    - E.g. rapid deployment forces (Germany, the Netherlands, Finland)
  - UN
  - ...
- National defence





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# *Net-centricity*



- *One core network*
- *Several access networks*
- *Service based architectures*
- *Multi-national coalitions*
- *Collaboration btw authorities*
- *Sensor networks*
- *Weapon systems*
- *Personal area networks*
- *...*



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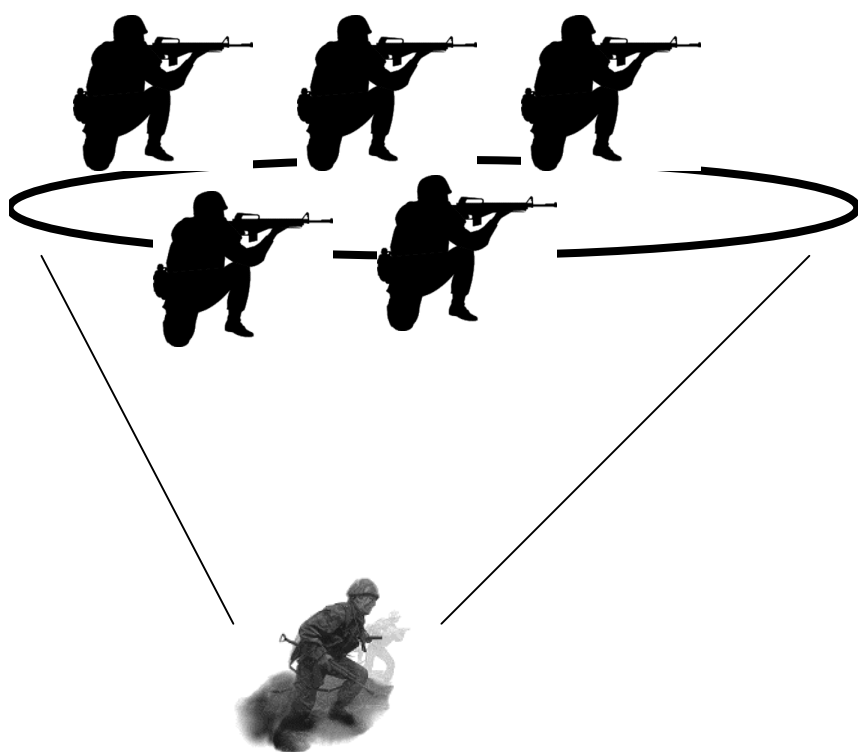
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# Scenario 1



## **Performance monitoring:**

- **Heart rate monitoring of the troops**
- **Time in HR intervals (% of max)**
- **Shape of troop & expectancy to perform**
- **Temperature & humidity**
- **HR at rest**
- **The number of troops alive**



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## ***Scenario 2***

- Dynamic operational network
  - peer-to-peer method of info sharing
- Capability to "sense" an upcoming attack
  - let the enemy in
  - go into stealth networking mode
- Honey networks
  - keep your friends close, but your enemies closer (J.R. Ewing, character from Dallas)
  - control the enemy
    - what are his intents
    - feed him disinformation



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## *Scenario 3*

- Self-preserving networks
  - stealth networking
    - sense the attack, run and hide
  - if hit, automatically self-organize
    - self-healing networks
  - when new nodes become available, dynamically restructure the network
- In ad hoc networks nodes participated in routing, in self-preserving network nodes participate in management (in an ad hoc fashion)





# Summary

- We have seen 1G-4G, but now what?
- 5G is important to Finland, because we have lost our status as an IT leader
  - we still struggle with a condemned 3G while the rest of the world is deploying 4G
  - 5G may get us back on track, IF we do something now
- Be creative; technology is just a tool, your imagination is the guideline!

