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Requirements for the SKA

Paulo André
Domingos Barbosa
Cláudia Camacho*
Rogério Nogueira

instituto de telecomunicações
creating and sharing knowledge for telecommunications

Signal Transport for SKA : from antenna to station to correlator

- Terabits of data ; very high traffic (200x WIT 2009)
- Time critical transmission (response of telescopes), requiring minimal delay
- Wide Spread Areas, continental sizes.
- Missing or minimal infrastructure
- Service: building, maintaining, operating

Signal Transport for SKA : from antenna to station to correlator

- **Huge progress in available technology**
- 9.6Tbps with 100G/channel
- Synchronization options with low delay and jitter
- Up to 2500km without regeneration -> less equipment
- High degree of automation

Signal Transport for SKA : from antenna to station to correlator

- Choose future-proof technology, easily upgradable and scalable
- Choose and install fiber infrastructure
- Choose how to build and minimize maintenance, and operating costs
- Guarantee low cost/bit

StaN related visits/workshops:

- Feb 2010 (Lisbon) - AAVP visit @ Nokia Siemens Networks (NSN) Portugal.
- May 2010 (Lisbon) - AAVP, SPDO, IT, CICGE ; @ NSN
- Sep 2010 (Aveiro) - 4th Radionet Enginering Forum Workshop ; with presence of Eriksson, NSN, SPDO, South Africa, Europe.

- Overview of existing technology; on custom made for radioastronomy vs general industry driven products
- Forecast on industry standards and plans --> discussion on availability of high-performance components & parts for SKA systems within SKA timeframes.
- I/O impact on antenna and correlator buffers.

Contents

- **What are the nonfunctional requirements for the SKA in terms of:**
  - Network Management
  - Swappable Units
  - Line-Side and Client-Side Interfaces

- **40G Transmission vs 10G?**
  - Commercially availability today
  - Market Drivers
  - Technical Issues
  - Cost & Power drivers?
- **Higher Transmission rates, ie 100G?**
- **Green energy powered? Self-sustainable?**

Nonfunctional Requirements

- The following slides describe the nonfunctional requirements for the SKA.
- In order to achieve them, an intensive research of today's commercially deployed and available technologies in the market was made.
- More than 20 companies were found, which provided all the information on their products needed for this study.
- A complete list of the standardized technologies and their features was created and through that list it was possible to define the main requirements for the SKA.

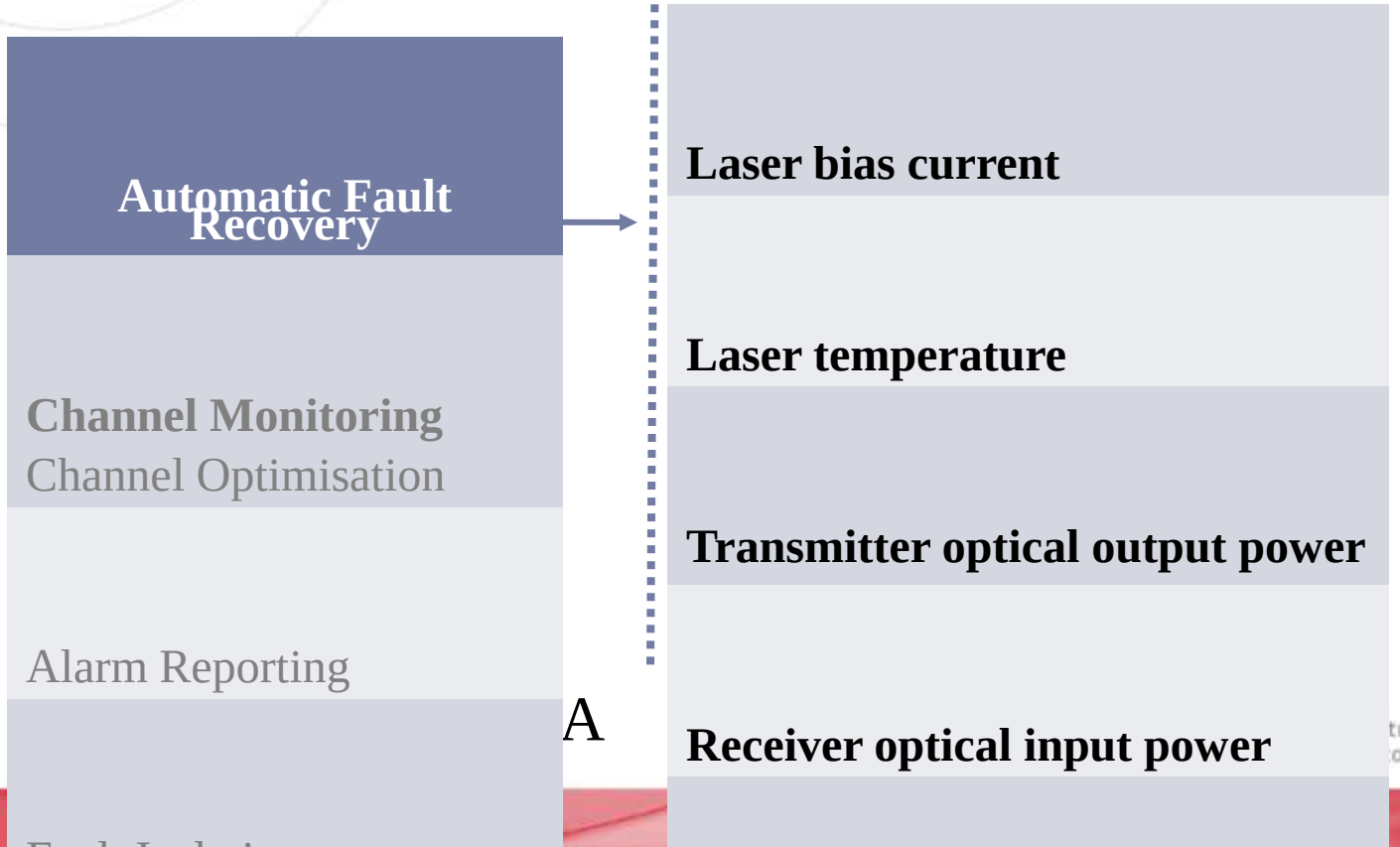
Network Management

- Network management is essential to ensure efficient and continuous operation of any network.
- The table below describes the main requirements in terms of network management for the SKA.

Automatic Fault Recovery	Isolation, Protection and Recovery	Management layer interfaces
Channel Monitoring Channel Optimisation	EN 300 386 EMC	SNMP interface CRAFT interface TL1 interface
Alarm Reporting	EN 55022 - Radiated emissions	Ethernet interface RMON interface
Fault Isolation	EN 61000-3 Harmonic current emissions	Automatic switching/ Multi section protection ASP/MSP

Network Management

- Each main requirement of the previous table has several sub-requirements to be considered for the SKA.
- Taking Channel Monitoring from Automatic Fault Recovery as an example:



Swappable Units

- Scalable capacity, faster provisioning, spare management and low costs are some of the SKA demands. The following table lists some of the ways to achieve them.

Swappable Units
Replacement of units under power (hot swappable) Field replaceable units Pluggable, interchangeable, and tunable units
Local configuration and upgrade capacity Remote configuration and upgrade capacity
Scalable number of channels Self tune capability when new wavelength channels added Any mix of services on a single card

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Line-Side and Client-Side Interfaces

- Depending on the implementation scenario of the SKA, the table below shows possible configurations for the line-side and client-side interfaces.

Data Rates	Protocols	Modulation Formats	Optics
• 10G • 40G • 100G	• SONET/SDH: OC-48/ STM-16, OC-192/ STM-64, OC-768/ STM-256 • G.709 OUT-2/-3 • Gigabit and Fast Ethernet • 10GE WAN/LAN PHY • ESCON, FICON • 10G Fibre Channel	• Optical DuoBinary • RZ, NRZ • DPSK, DQPSK • RZ-DPSK, NRZ-DPSK • RZ-DQPSK • Coherent PMD-QPSK • Coherent CP-QPSK	• Pluggable XFP • Pluggable SFP

- Continued growth of bandwidth and the pressure to reduce transmission costs will lead to the need for higher bit rates, and consequently, new protocols and modulation formats.
- For the SKA it will not be an exception, and for that, the equipment must have specific features.

Line-Side and Client-Side Interfaces

- All the features for the line-side and client–side interfaces were listed but only some of them are described here due its high number.

Line-Side Features	Client-Side Features
• CWDM and DWDM Transport • Forward Error Correction (FEC) and Enhanced FEC • Coherent Detection • PMD and CD tolerance and DCM free optical design • 3R operation (reshape, retime, regenerate) • Remote access and highly effective automation • Full band tunable transponders and transceivers • 10G, 40G, 100G transponders • Mix of services in one card • Common line cards and chassis • Regenerator functionalities • National, regional, metro reach	• Multi-port, multi-protocol transponders with per-port service selectivity • Multiplexing transponders to support asynchronous multiplexing • Software programmable ports on the muxponders • ITU application codes G.691 I-64.1 (GR-253 SR-1) • Multirate multireach client interfaces

A look into High transmission rates ?

- **Four main market drivers of introducing 40G into long haul systems:**
  - Bandwidth growth
  - Reduction of Transmission Costs
  - Need to Relieve High-Capacity Bottlenecks
  - Support for the New Generation of IP Backbone Routers

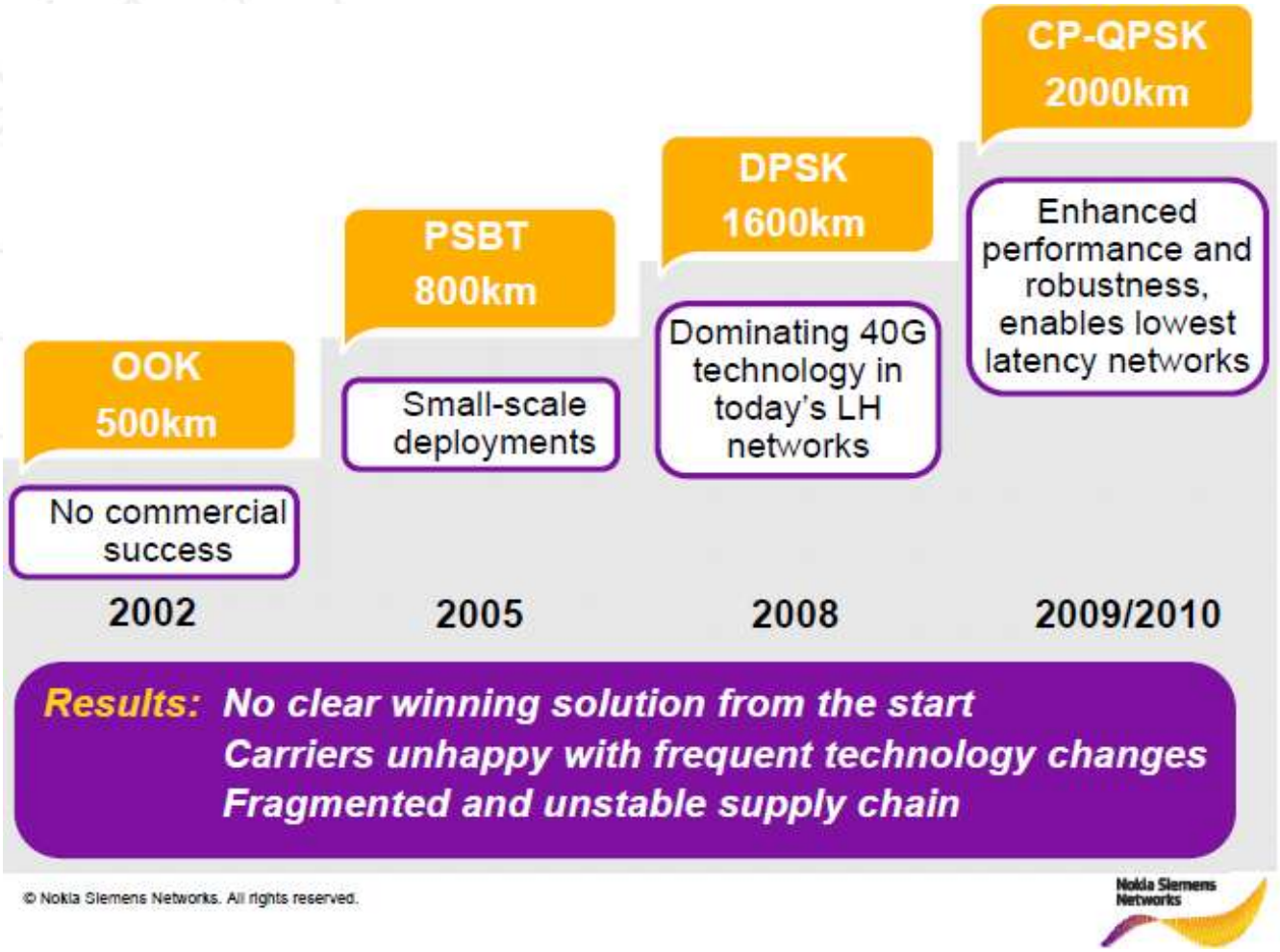
- **Technical Issues for 40G DWDM**
  - OSNR Sensitivity
  - Chromatic Dispersion
  - Polarization Mode Dispersion
- **Forward Error Correction (FEC), Alternative Modulation Formats and Dispersion Compensation Techniques solved these issues, enabling commercial deployment of 40G technology**

BUT: 50% of the world internet traffic already runs on 40G servers (availability of components).

Caveats: 40G - Why Did It Take 10 Years for 40G To Take Off?

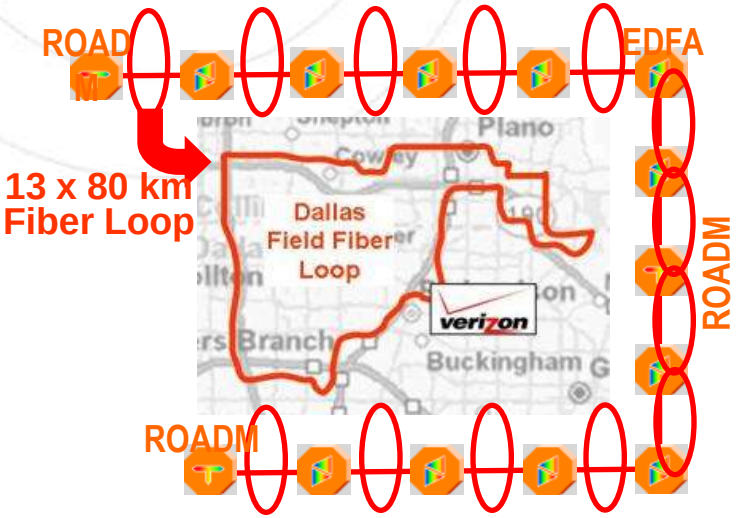
- Courtesy of NSN

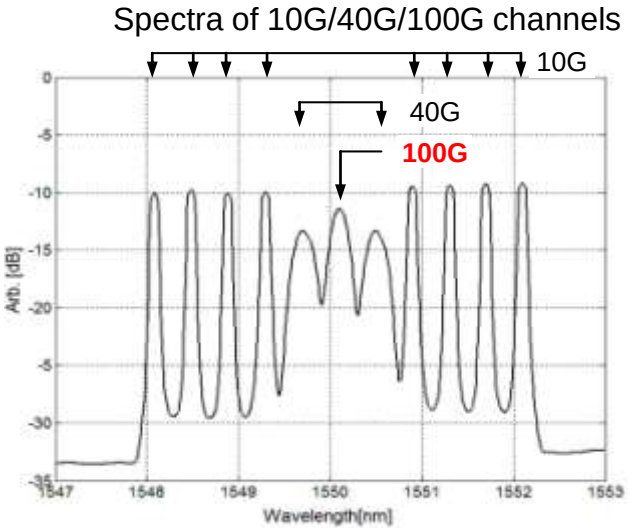
The Four Technology Steps in 40G



Convergence: 2008 - Field Trial mixed 100G/40G/10G over 1040 km ; NSN and Verizon

- **Experimental setup**:
  - 100G mixed with 40G and 10G over field deployed fiber, record distance 1040 Km.
  - 100G using 50GHz compatible **CP-QPSK**, 40G using DPSK, 10G using NRZ.
  - Standard chromatic dispersion map & PMD tolerance >23 ps mean DGD
- **Courtesy of NSN**

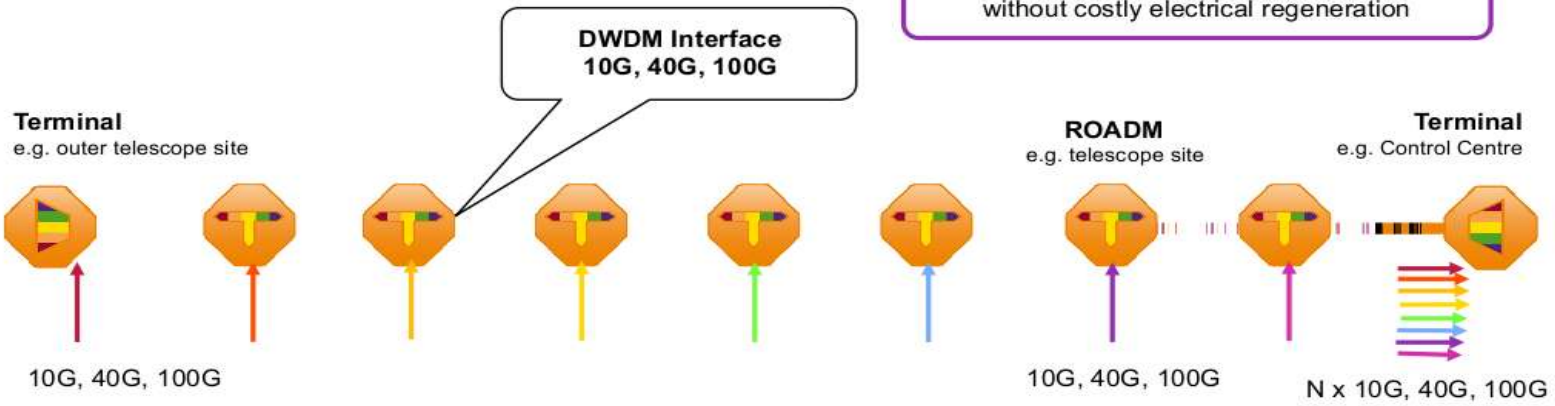




World record reach of 1040 km. Mixed transmission of 100G/40G/10G on 50GHz equally spaced grid.
Addressing also green power solutions

DWDM is the only technology to cope with radio astronomy challenges

Reach: from metro reach to > 2000 km without costly electrical regeneration



10G
- Mature technology, widely deployed
- Mass market prices
- Requires fibre rich infrastructure
- Huge amount of equipment needed (OPEX: floor space, power consumption)

40G
- Ramp up started now, fast price decline
- Less fibre, less equipment (OPEX)
- New modulation formats (CP-QPSK) for increased reach, robustness against physical effects and reduced delay

100G
- Currently mainly trials
- Significant deployments expected to start in 2012
- Lowest fibre count, lowest OPEX
- Same reach as with 40G

DWDM: Dense Wavelength Division Multiplexing
ROADM: Remotely re-configurable Optical Add Drop Multiplexer

Nokia Siemens Networks

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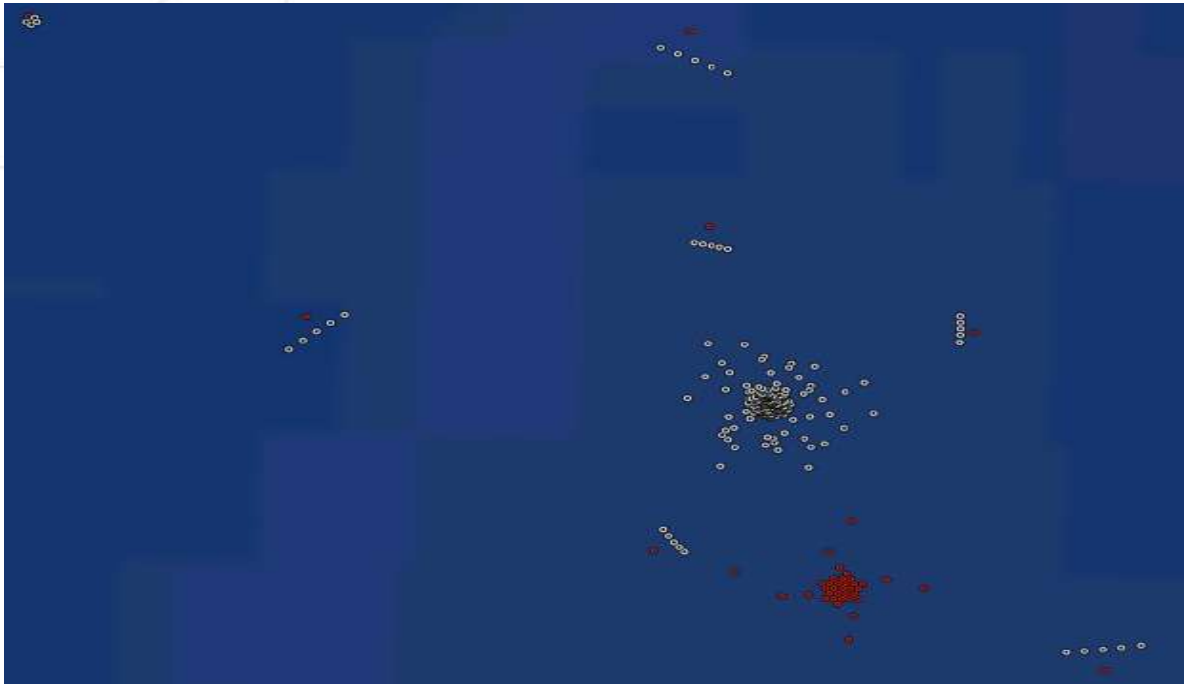
First pass on full SKA network configuration - Phase 1

- Analysis of network behaviour and configuration dependence.
- Receptor is one way transmission
- M&C data is estimated at an additional 10 Gbps bi-directional transmission/ receptor
- SKA 1design must be SKA 2 compliant.



Conclusions I

- **Nonfunctional requirements:**
  - Implementation dependent
  - Gives good knowledge of the SKA needs.
  - Achieved a good mapping of available options
  - Released for comments.

- **Market mature and economically viable for 40G standard.**
- **Positive forecast for 40G/100G within SKA timeframes (possibility of SKA / AAVP field trials with exclusive 100G equipment - > at the forefront of ICT high-performance testing of Networks)**
- **Cause for cautious optimism (albeit many variables and scenarios still to be controlled/ analyzed) as components availability will converge for volume**

Conclusions II

- Analysis will take new technology and pricing forecasts
- Weighting custom made needs vs industry providers capabilities.
- Industry is moving towards Coherent systems for long hauls.
- Good examples for mixed standard networks; easily upgradable and scalable.
- Triggered interest of major word leading industry (ex: SPDO NDA with Nokia Siemens networks)
- SKA phase 1 simulations and costing in the horizon.

Thank You