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# **Multi-hop Wireless Access: a key enabler for IMT-Advanced**

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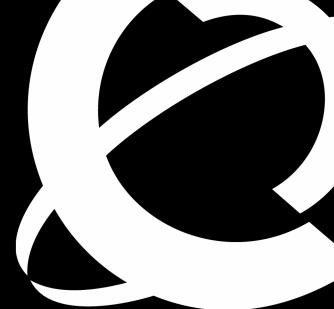
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# Outline

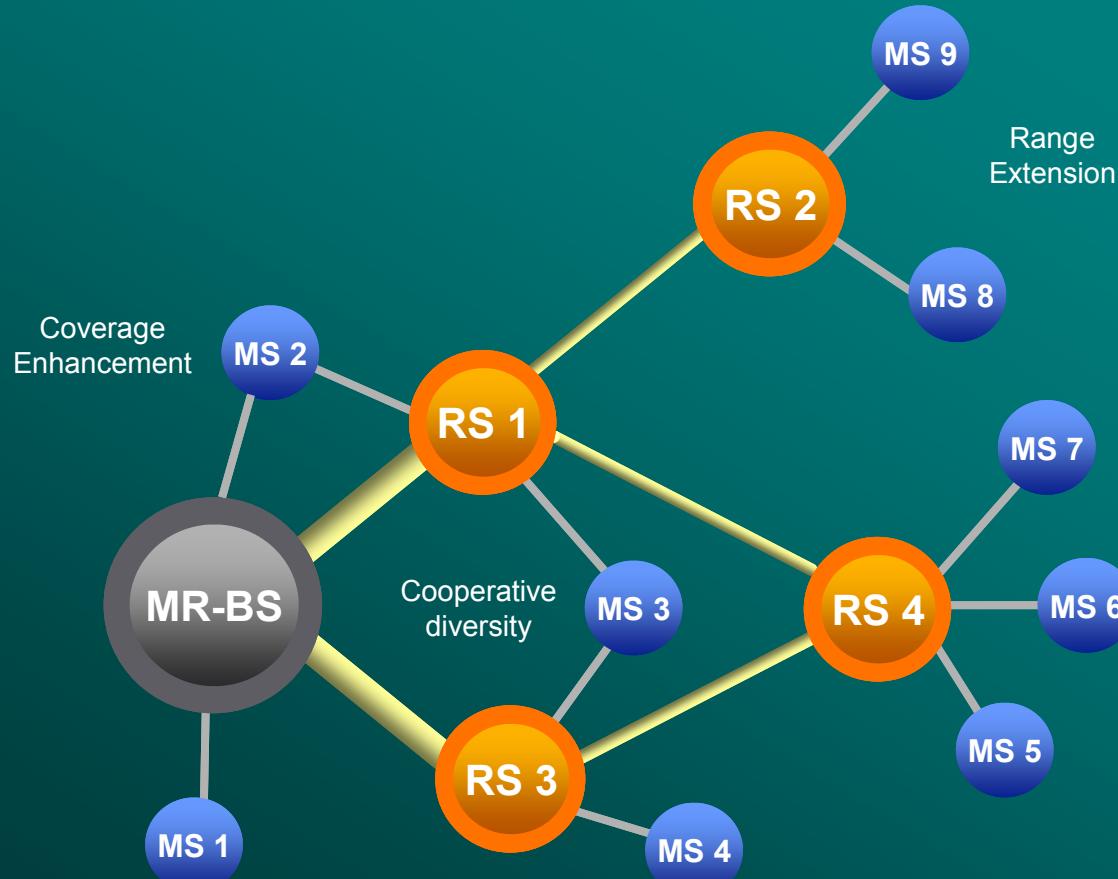
- **Multi-hop Wireless Access**
  - Illustration of the concept
  - Vocabulary
- **Usage Models**
  - Fixed infrastructure model
  - In-building coverage model
  - Mobile platform coverage model
- **System Performance & Benefits**
- **Key advantages for IMT-Advanced**
- **Example of System Architecture**
- **Summary**

# Illustration of multi-hop relay coverage



Legend:

- MR-BS Multi-hop Relay Base Station (manages the RSs)
- RS Relay Station (can be fixed, nomadic or mobile)
- MS Mobile Station





# Some Definitions

- **relay station (RS):** A station whose functions are:
  - 1) to relay user data and possibly control information between other stations, and
  - 2) to execute processes that indirectly support multi-hop relay.
  - NOTE: All RSs are managed by an MR-BS, but they may have some control of relay functions within their neighborhood.
- **MR base station (MR-BS):** A base station which has extended functionality to support multi-hop relay.
  - NOTE: Relay stations that support a particular MR-BS are managed by that MR-BS.

# ITU-R Vocabulary

## (Recommendation ITU-R M.1797)

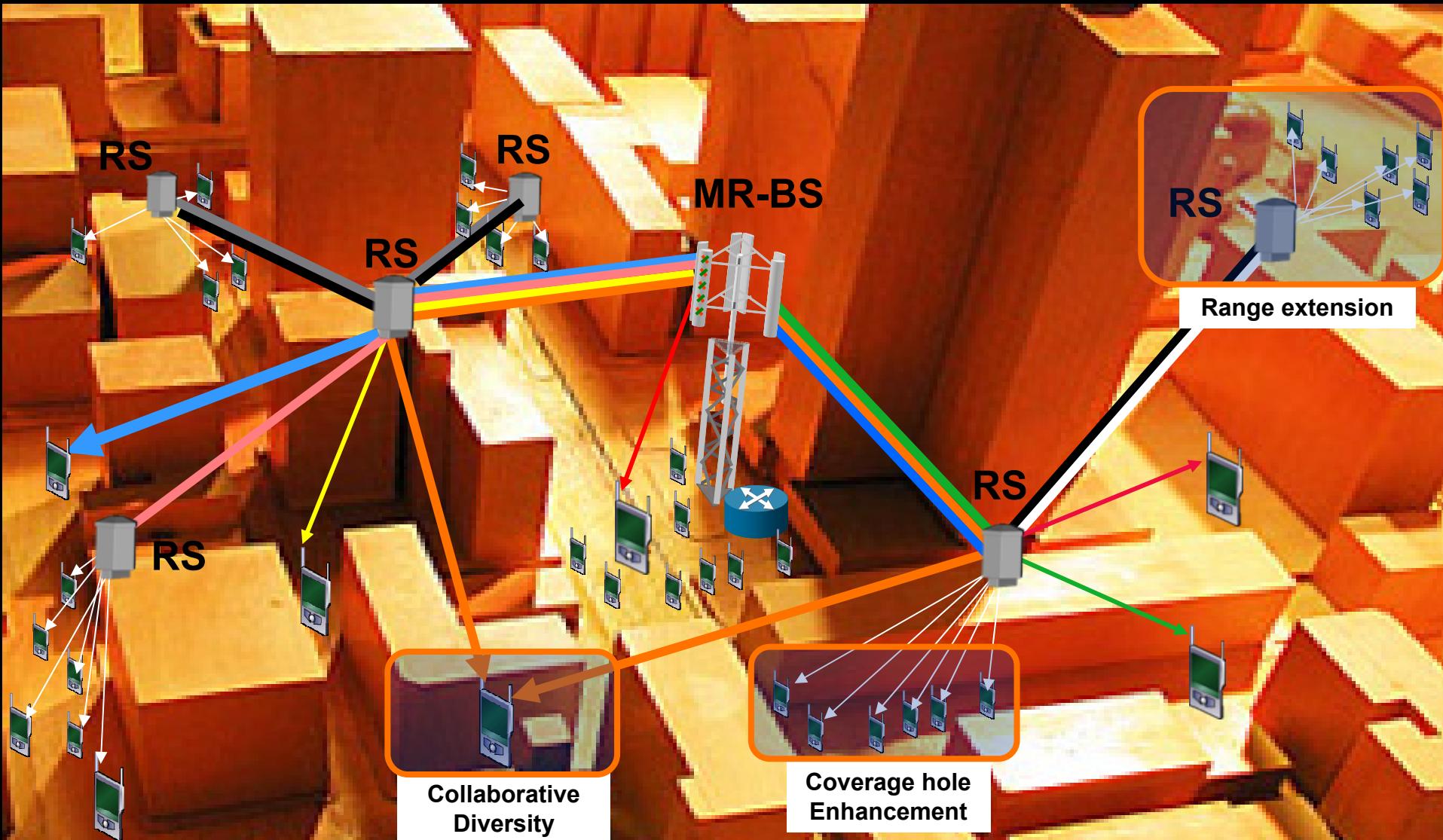


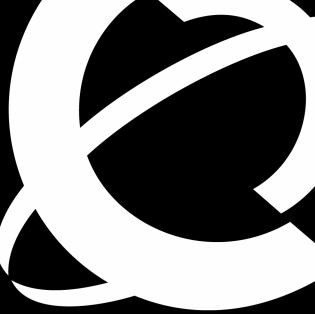
- **Mesh network, wireless mesh network**
  - A network in which there are two or more paths to any node.
  - NOTE – There are two types of mesh networks: full mesh and partial mesh. In a full mesh every node is connected to every other node in the network. In a partial mesh some nodes may be organized in a full mesh scheme but others can only connect to some nodes in the network.
- **Relay, relay station, wireless relay**
  - A station that performs message/signal transfer without any reference to a user application.
- **Relay network, wireless relay network**
  - A network of *relay stations*.
  - NOTE 1 – Relay networks can be one-hop or multi-hop. One-hop relays are implemented with P-P and/or P-MP techniques. Multi-hop relays are implemented using MP-MP techniques to form a mesh.
  - NOTE 2 – The *relay stations* in a network can be fixed, nomadic or mobile.
- **Infrastructure, network infrastructure**
  - A set of interconnected network elements that support telecommunications.
  - NOTE – The network infrastructure is generally understood as the fixed network excluding the terminals, and may include both the access network and the core network.
- **Ancillary infrastructure, ancillary network infrastructure**
  - A set of interconnected nomadic and mobile network elements, providing subsidiary support to telecommunications.
- **Client relay, client relay station, client wireless relay**
  - A *relay station* implemented on a client device.
- **Client relay network, client wireless relay network**
  - A network of *relay stations* implemented on client devices.
  - NOTE 1 – The relay stations in a client relay network can be fixed or nomadic.



# Fixed Infrastructure Usage Model

*Lower CAPEX & OPEX approach to expand infrastructure*





# In-Building Usage Model

- In carrier operator's networks, 70% of the traffic is indoor
  - Require the need for cost effective in-building solutions
- The carrier-host enterprise wireless access solution enables seamless ubiquitous mobile broadband service
  - Enables the extension of the carrier network deployment into enterprise space





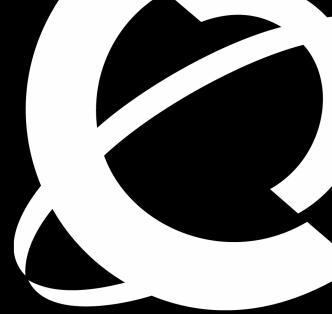
# Coverage on Moving Platform Model

*RS node supports the mobility deployment*

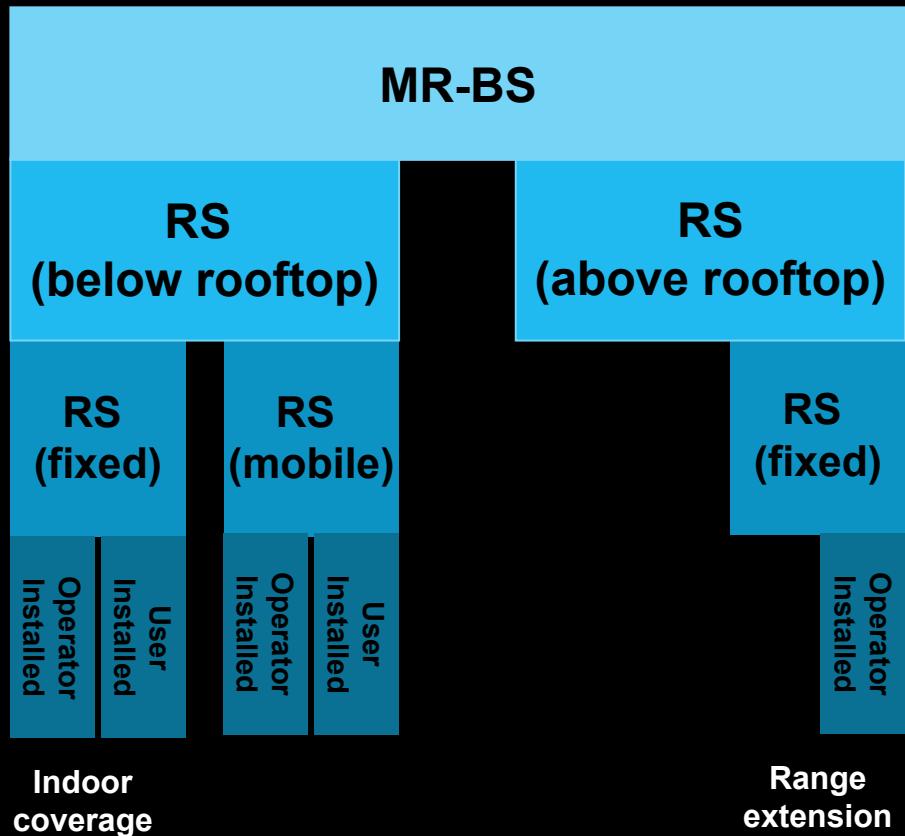


**Unique advantages over the conventional analogy repeater**

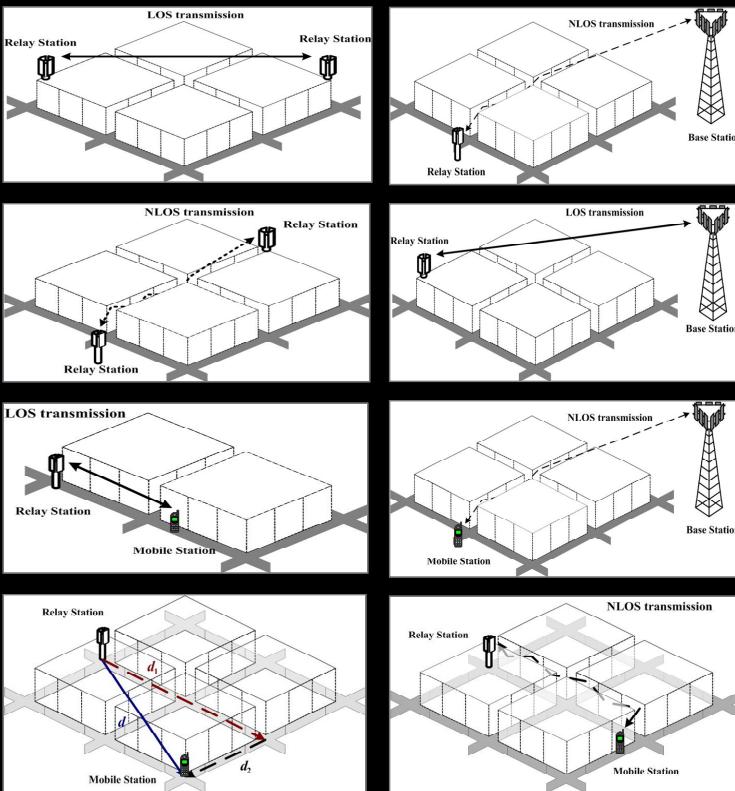
# RS Node Deployment Scenarios



## Category of RS Node Usage Models



## RF Propagation Model



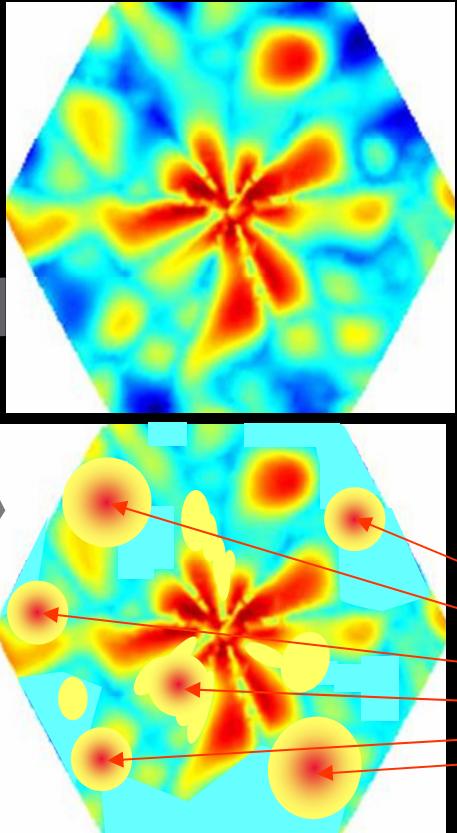
Need to support most of the practical RS deployment cases



# Value Proposition to the End User

## **Network Performance**

- Simple 2-hop Relay Improves Data Coverage



- Eliminates coverage holes
- Intelligent digital relay
- No planning required
- Deployed incrementally on-demand
- Can be rolled-out in parallel with existing networks

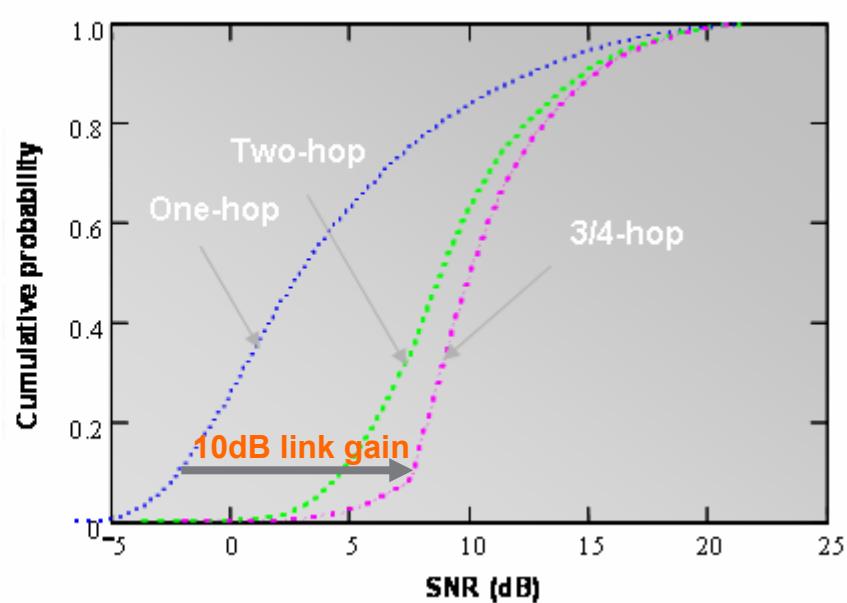
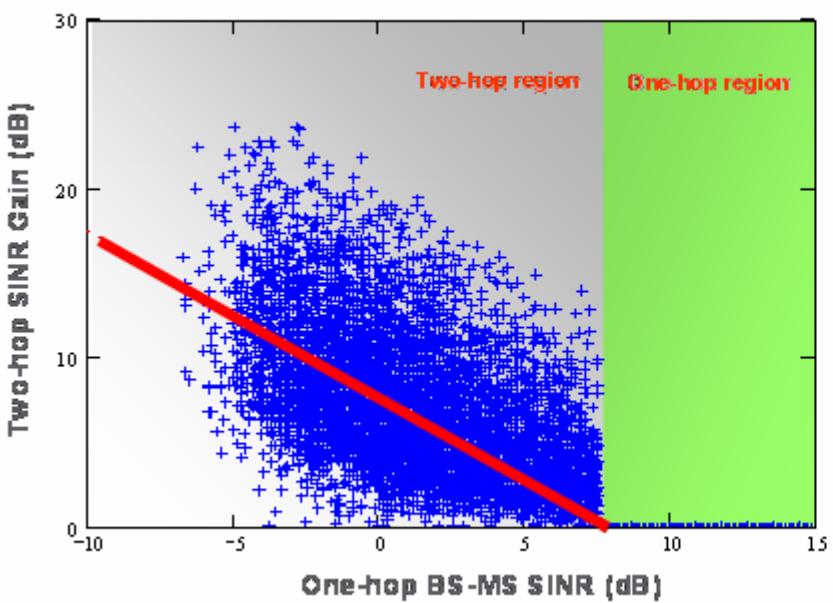
Relay Stations added

***Multi-hop relay can enhance the cell edge user throughput and the user SINR***



# Multi-hop Network Performance Benefit

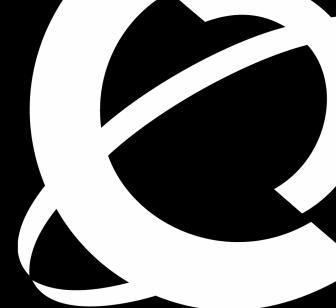
- Multi-hop can significantly enhance the access network coverage
- RS node enables to eliminate the very low SNR spots in the network



***Multi-hop technology can improve the uniform user data rate across the network***

# Value Proposition to the Operator

## Network Cost



### Simulation conditions

Suburban environment

Terrain type A

Spectral efficiency

2.5 bit/s/Hz/km<sup>2</sup>

Coverage (outage) 95%

RS antenna gain

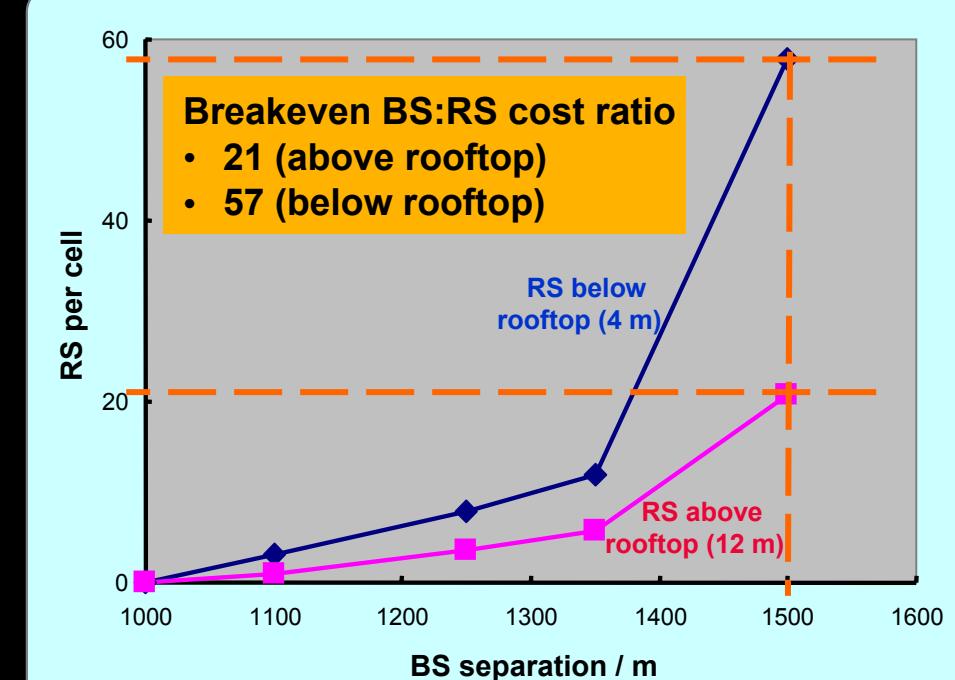
4 dB (receive)

2 dB (transmit)

RS transmit power

2x28 dBm (above rooftop)

2x24 dBm (below rooftop)

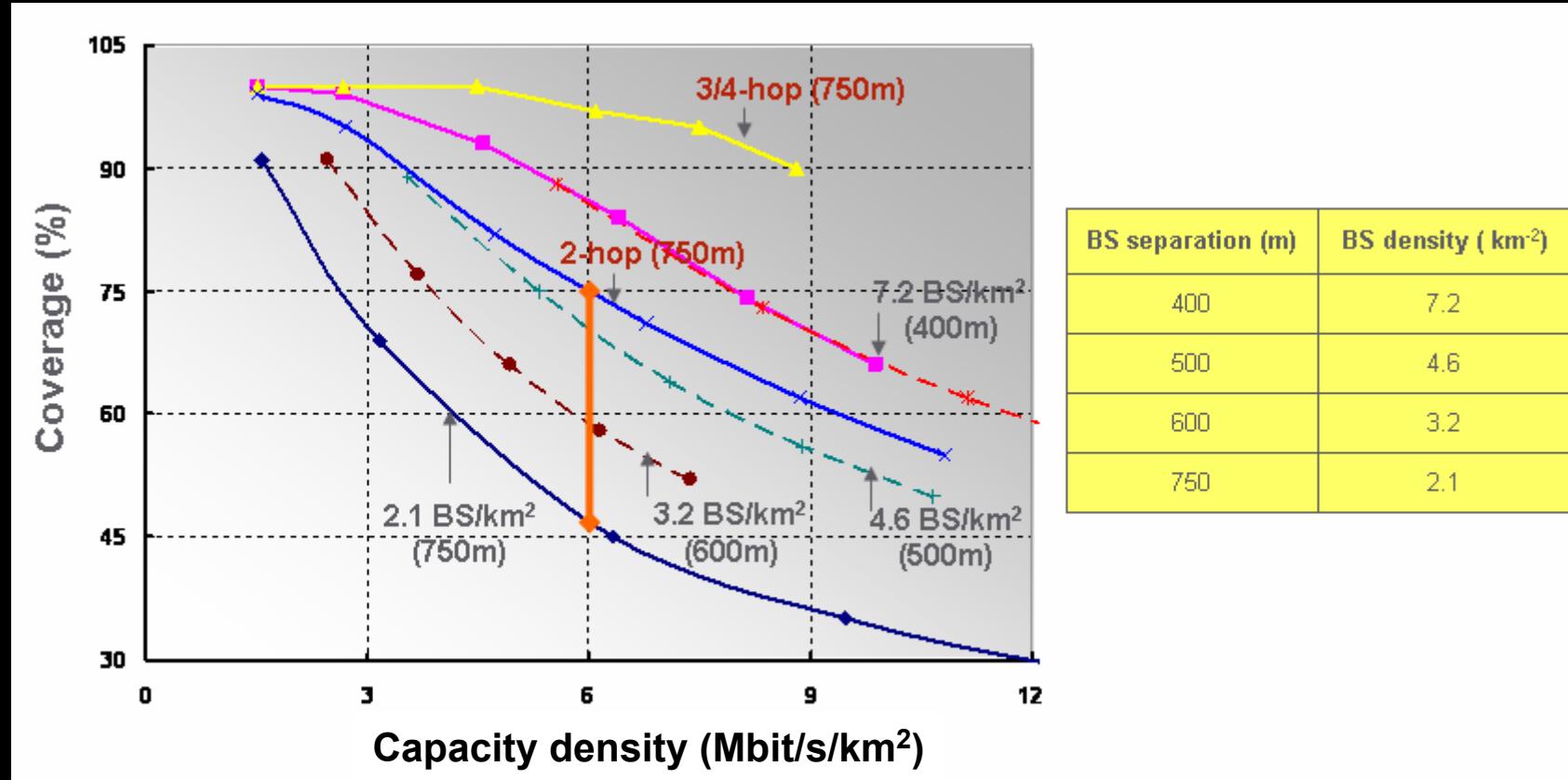


Adding relays compensates for greater base station separation

**Deployment of RS nodes can reduce the macro-cell BS deployment density**



# Example of CAPEX Investment Comparison Macro-cells with Relay Systems



*The use of RS nodes can deliver large network cost saving compared to increasing macro-BS density to achieve the same coverage performance*

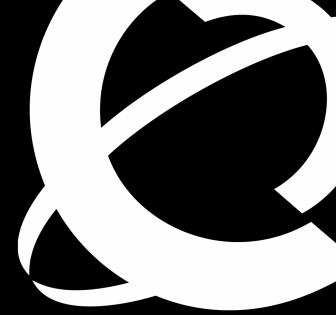


# System Comparison Example

## *With and without multi-hop relays*

- At 90% coverage,
  - deploying a 2-hop access system with 6.3 MR-BSSs + 32 RSs per square kilometre provides the same capacity density as a one-hop system with 13.8 base stations.
  - Therefore, 7.5 ( $=13.8-6.3$ ) base stations can be traded for 32 relay stations and achieve the same performance.
- If multi-hop diversity based routing is enabled,
  - deploying a 2-hop system with 6.3 MR-BSSs + 32 RSs per square kilometre provides the same capacity density as a one-hop access system with 21.6 base stations.
  - In this case, the same coverage can be achieved if 15.3 ( $=21.6-6.3$ ) base stations are traded for 32 relay stations.

# Multi-hop Technology is a key enabler for IMT-Advanced: Key Advantages

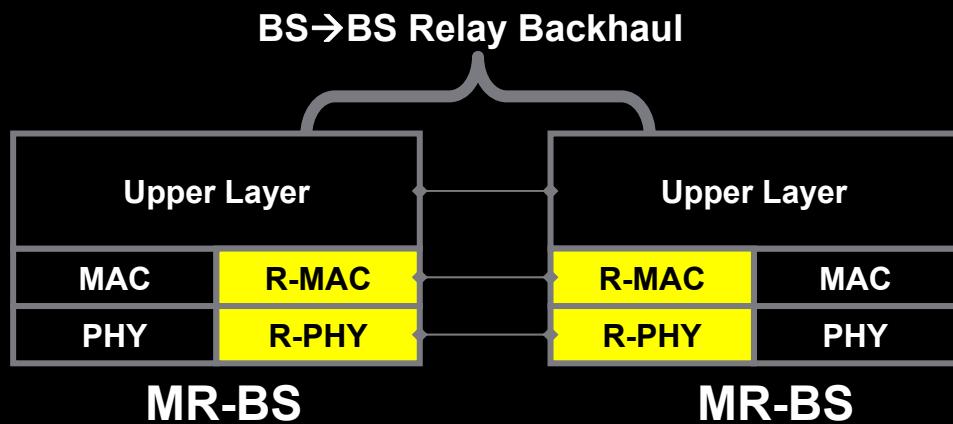
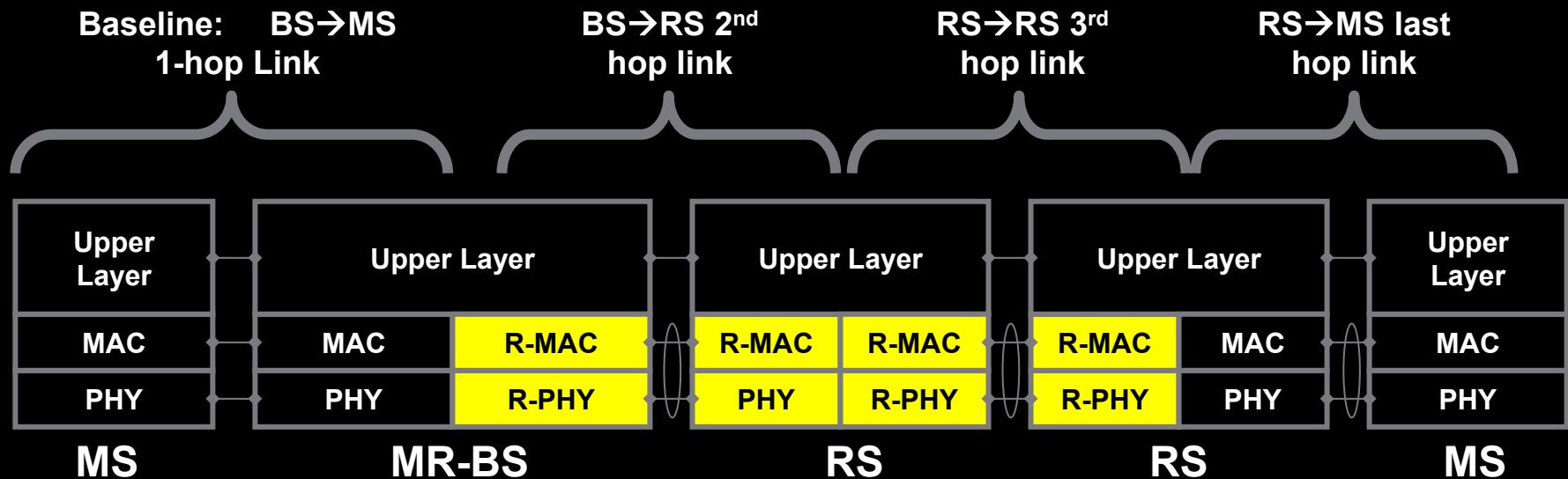


- Uniform broadband experience
  - Overcome user throughput dependency on distance-to-BS
- Licensed in-band relay
  - Network aware
- Operator/Network controlled
  - Operator ownership model, ensured security and QoS
- Self deployment low power RS node
  - Truly zero-foot print
- Transparent to MS/CPE
  - Auto-configure with BS only
- On-demand basis
  - Enable continue network improvement and minimize investment
- Low cost network to grow customer
  - Saving the macro-BS densifying cost

To enable true broadband experience – uniform throughput



# Example of Multi-hop Architecture





# Summary

- Have described multi-hop wireless access as a technique to improve coverage and data throughput for all users.
- Have described several usage/deployment models.
- Have described the key advantages of multi-hop wireless access networks.
- Have shown an example of multi-hop architecture.

Multi-hop technology will be a key enabler for IMT-Advanced



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