Containing exposure in 5G networks, a perspective from LExNet

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Why do we need to think about exposure?

- The jury’s still out!
- Public concern not going away
- World Health Organisation and International Research Agency on Cancer classified exposure as “possibly carcinogenic to humans”.
- Proliferation of wireless devices is growing!
- Thus energy and exposure matter to 5G communications.
## A move from Green Wireless to Blue Wireless

<table>
<thead>
<tr>
<th>Green Wireless</th>
<th>Blue Wireless</th>
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<tbody>
<tr>
<td>Reduce base station energy costs</td>
<td>Also reduced coupling to user on uplink</td>
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<td>No differentiation between users</td>
<td>Some users may be more sensitive to exposure – e.g. age.</td>
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<td>Differentiation between usage patterns is low</td>
<td>Usage means a lot to exposure and needs to be factored in</td>
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<td>Battery life of user device</td>
<td>More strategies – e.g. low SAR, time transmission</td>
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What metric do we use – exposure index over a day over a population

Transmission periods in a day
- A given “population” of people in the network
- A set of locations in the network
- A set of RATs in the network

Downlink power partly affects exposure
More so uplink power and SAR – to some extent time too

Time of exposure and posture accounted for in uplink/downlink

\[
EI = \sum_{i}^{N_{\text{Periods}}} \sum_{j}^{N_{\text{Individuals}}} \sum_{k}^{N_{\text{Locations}}} \sum_{l}^{N_{\text{RATs}}} \left[ \left( \sum_{m}^{N_{\text{Usages}}} \sum_{i,j,k,l,m}^{t_{\text{UL}},\beta_{\text{UL}}} \right) \left( \frac{P_{\text{Tx}}}{P_{\text{Tx|Ref}}} \right) + t_{i,j,k}^{\text{DL}} \frac{\alpha_{\text{i,j,k,l}}^{\text{DL}}}{SAR_{l}^{\text{Rx}}} \cdot \frac{P_{\text{Rx}}}{P_{\text{Rx|Ref}}} \right]
\]
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Structure of project – how to reduce EI

- Exposure Scenarios
- Dosimeter Measurement
- EI Result
- Network topology and management
- Components and Transmission Techniques

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Questions we have to ask

- Do small cells = lower exposure?
- Can we compromise QoS for exposure? Is this a new consumer option?
- Can we narrow down the time of exposure and make a big difference?
- Can we really inform the user on how to control their exposure?
EMF and QoE trade offs

- Video uplink invites high exposure
- Radio Link Control (RLC) frames sent via eNodeB into internet protocol/user datagram protocol (IP/UDP) packets
EMF and QoE trade offs

- Aim to maintain an acceptable quality of experience with low EMF of video uplink.
- Send critical RLC frames (e.g. IP addresses and UDP ports)
- Reduce RLC frames such as retransmissions that would only enhance QoE.
- Jointly looks at lower power transmissions and hence lower SNRs at the eNodeB.
Low Exposure Beamforming Techniques

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Beamforming Techniques

- Reduced power density on the body of a user to a laptop – achieved by phase nulling.
Implementation of low SAR coding

- Use of coding compared to conventional coding: 78.8% reduction.
Where next beyond LExNet

- An adoption of the exposure index
- Usage in the context of network planning and management – demonstrated with dossimeter used in Smart Santander platform
- Ranking of component level technologies and transmission techniques to inform standards
Thank you!

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