# Device-to-Device Communication: Efficiency and Feasibility

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# Device-to-Device (D2D) Communication

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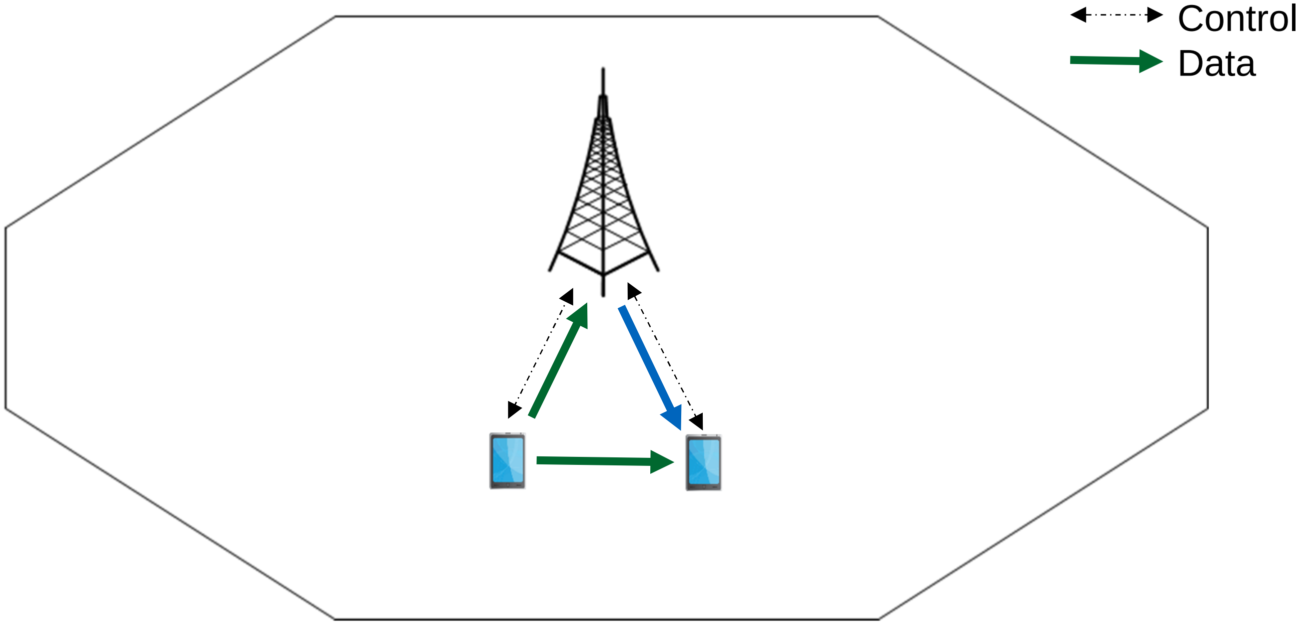
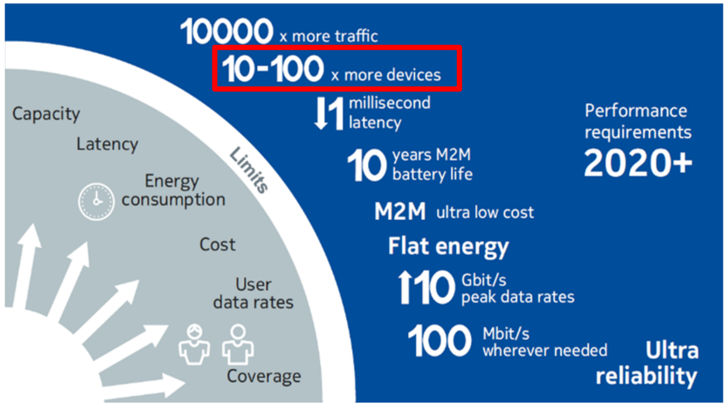



- “Network-controlled direct communication between devices without user-plane traffic going through any network infrastructure“ [1]
- “Network controls radio resource usage of the direct D2D links and the resulting interference effects.“ [1]

# Device-to-Device (D2D) Communication




The summary of key requirements for 5G [2]

- METIS Test Cases (TCs) for D2D:
  - Dense urban information society (TC2)
  - Shopping mall (TC3)
  - Stadium (TC4)
  - Traffic jam (TC6)
  - Open air festival (TC9)
  - Emergency communications (TC10)
  - Traffic efficiency and safety (TC12)
- „Great service in a crowd“ [1]

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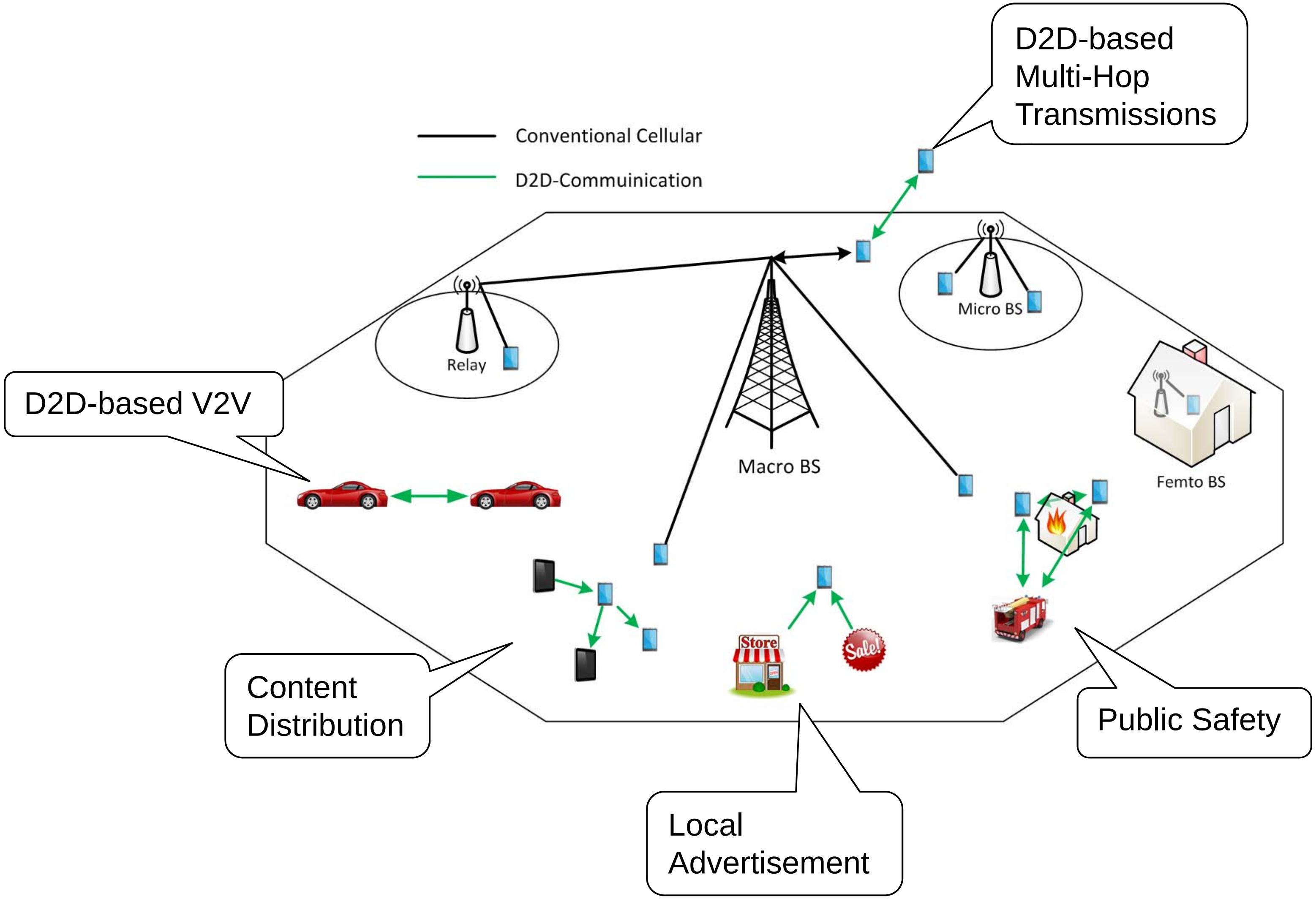
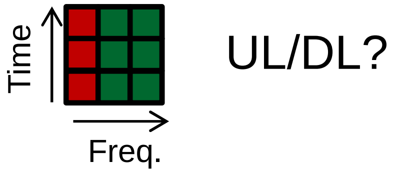


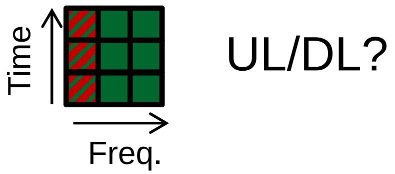
# Device-to-Device (D2D) Communication

Design Choices

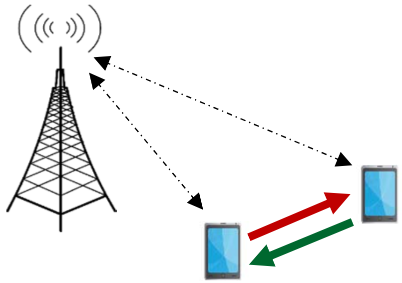
- Outband D2D
  - WiFi Direct
  - Bluetooth
  - ….
- Inband D2D
  - Overlay D2D



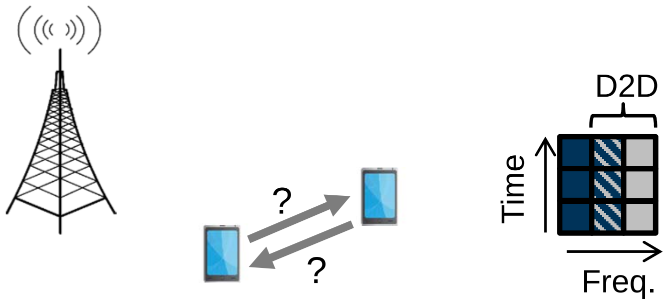

  - Underlay D2D




- Degree of Operator Control
  - Fully Scheduled

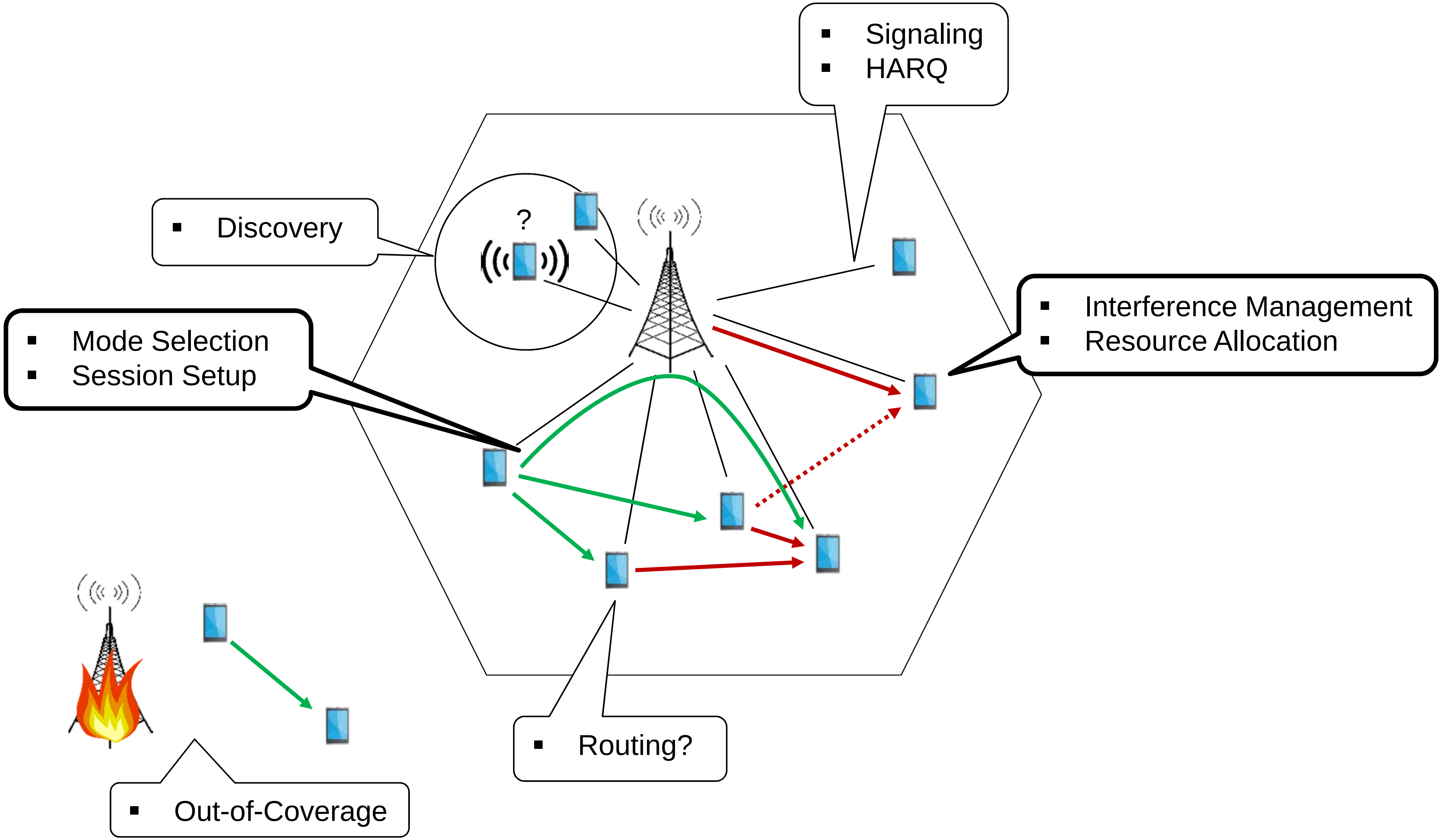


  - Fully Autonomous



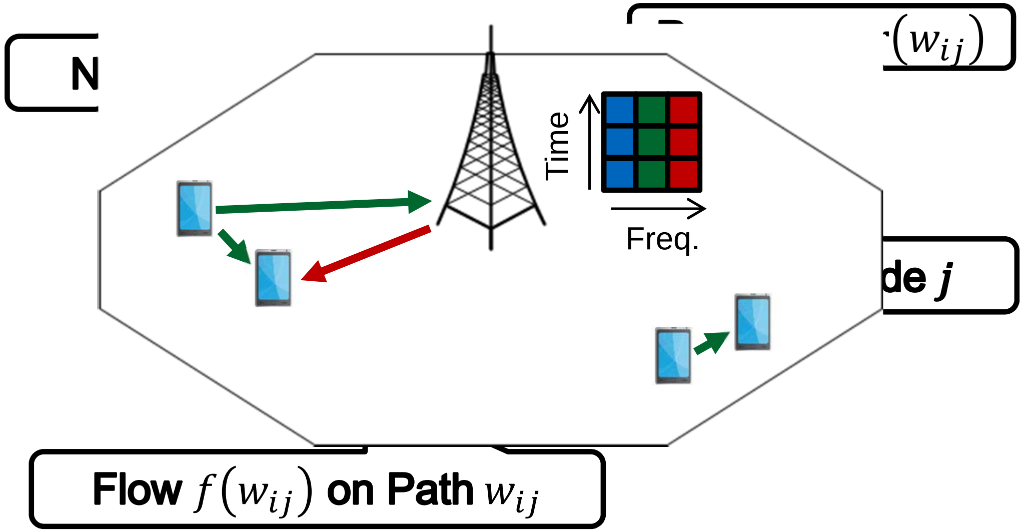
# Device-to-Device (D2D) Communication

## Research Areas



# Efficiency and Feasibility

# Flow-Based Resource Efficiency [3]



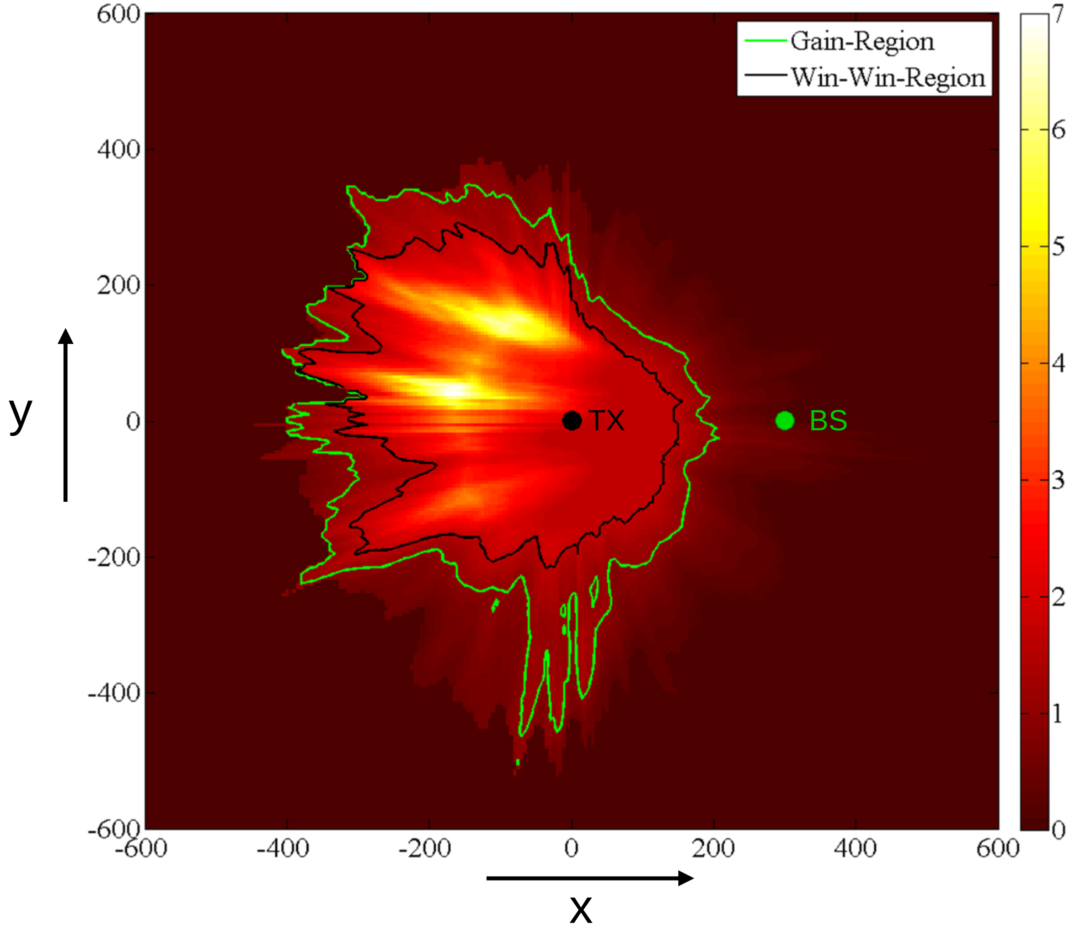

Three RAN-Gains of D2D [4]:

- *Proximity Gain*: High Rates, Low Energy & Delay
- *Hop Gain*: Less Resources
- *Reuse Gain*: Frequency Reuse

- Gains not captured by current metrics (e.g. Throughput, Reliability)
- Resource Efficiency: $RE(w_{ij}) = \frac{f(w_{ij})}{|r(w_{ij})|}$, can capture the gains
- Ongoing work: Resource Efficiency based…
  - …Mode Selection
  - …Routing
  - …Scheduling

[3] „Introduction of an Efficiency Metric for Device-to-Device Communications“, M. Klügel, W. Kellerer (2014)

# Flow-Based Resource Efficiency [3]

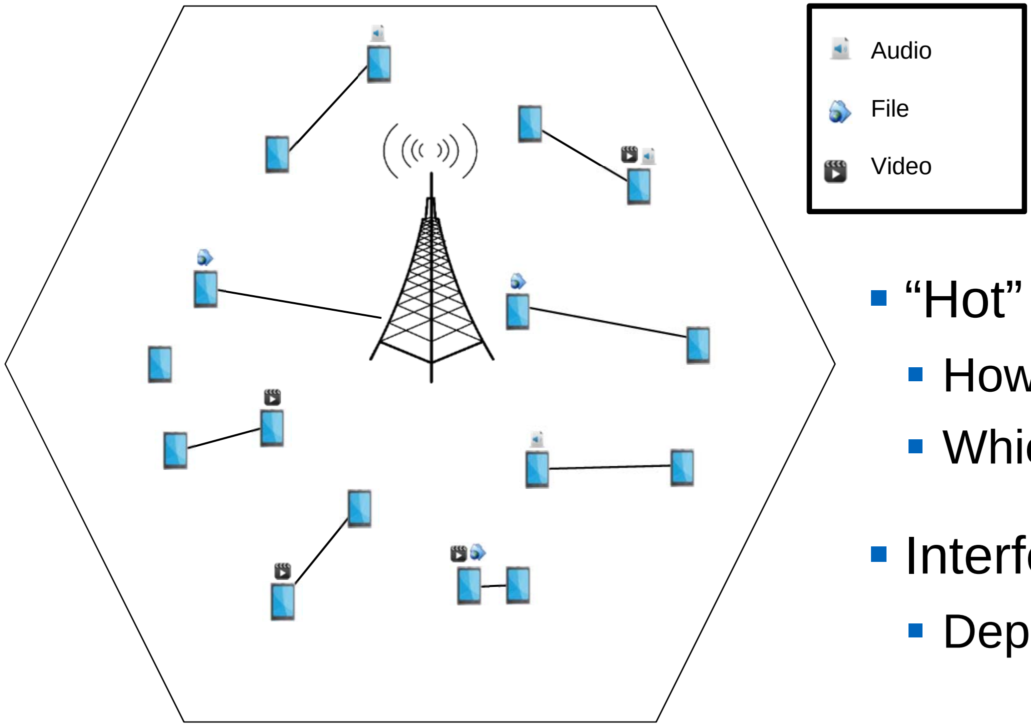



$$G_{D2D} = \frac{RE(w_D)}{RE(w_C)}$$

| Simulation Parameters | |
|---|---|
| Path Loss | With Log-Normal, Spatially Correlated Shadow Fading |
| Transmission Power D2D-TX / BS | 23dBm / 38dBm |

[3] „Introduction of an Efficiency Metric for Device-to-Device Communications“, M. Klügel, W. Kellerer (2014)

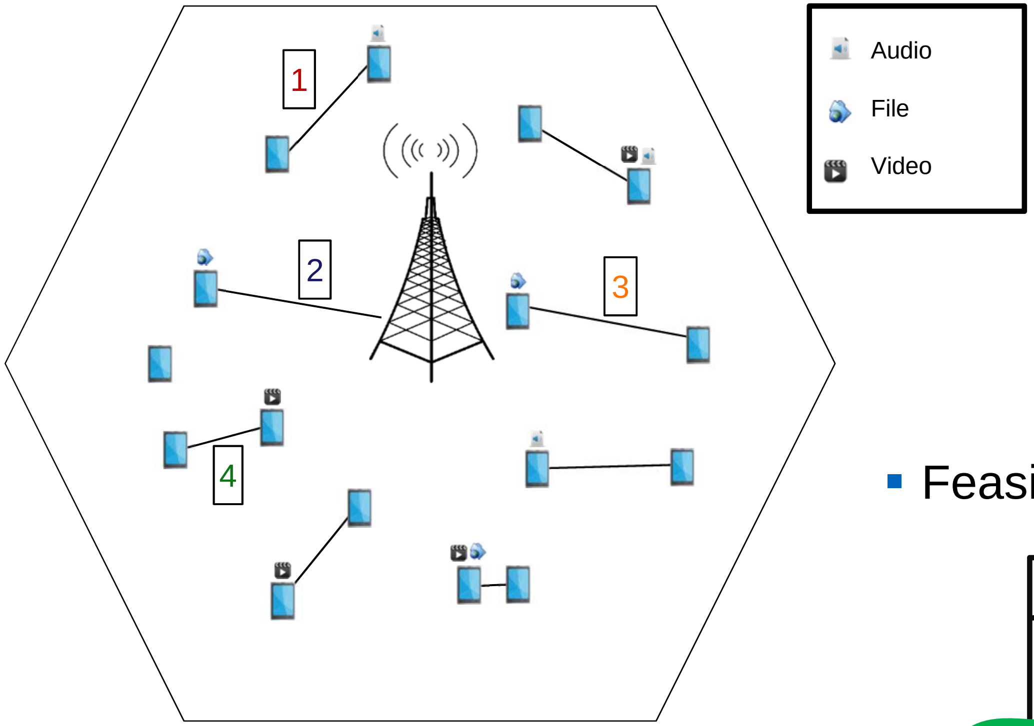
# Feasibility of Frequency Reuse




- "Hot" Questions:
  - How often can a frequency be reused?
  - Which pairs to choose for reuse?
- Interference is a major issue
  - Depends on Transmit Power, Channels

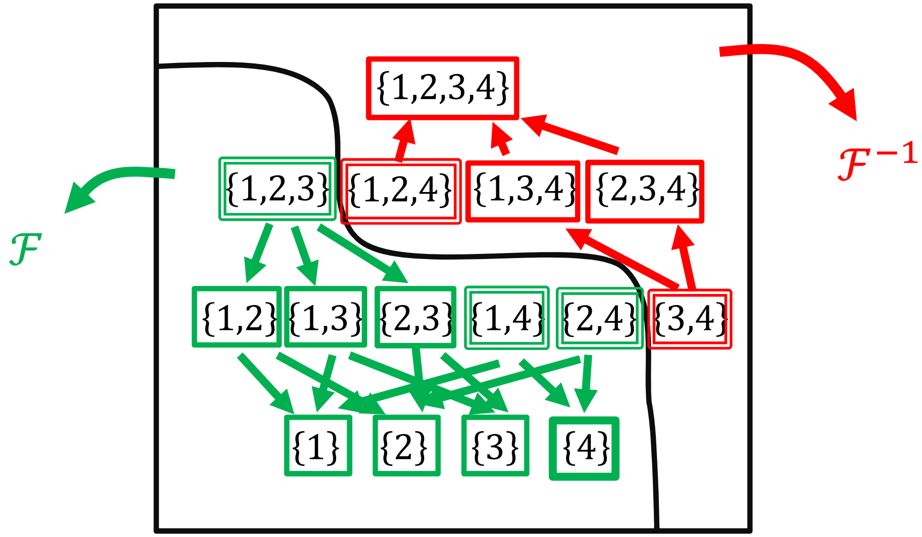
- "Feasiblity": There exists a set of transmit powers satisfying SINRs
  - Eigenvalue condition on channel gain matrix
  - Feasibility can abstract power control from scheduling
  - Underlying power control algorithms need not be known

# Feasibility of Frequency Reuse




- Possible directions:
  - Opportunistic reuse
  - Influence of network knowledge
  - Scheduling based on feasibility
  - Handling of heterogeneous PHY

- Feasible/Infeasible Link Combinations




$\mathcal{F}$: Feasible reuse set $\mathcal{F}^{-1}$: Infeasible reuse set

□: Basic Set

# List of References



| | |
|---|---|
| [1] | “Summary of Deliverable 6.2: Initial report on horizontal topics, first results and 5G system concept”; G. Mange, M. Fallgren et al. METIS (2014-03-31) |
| [2] | “5G use cases and requirements” Nokia White Paper (2014) |
| [3] | „Introduction of an Efficiency Metric for Device-to-Device Communications“, M. Klügel, W. Kellerer (2014) |
| [4] | “Design aspects of network assisted device-to-device communications”; G. Fodor, E. Dahlman et al. (2012) |