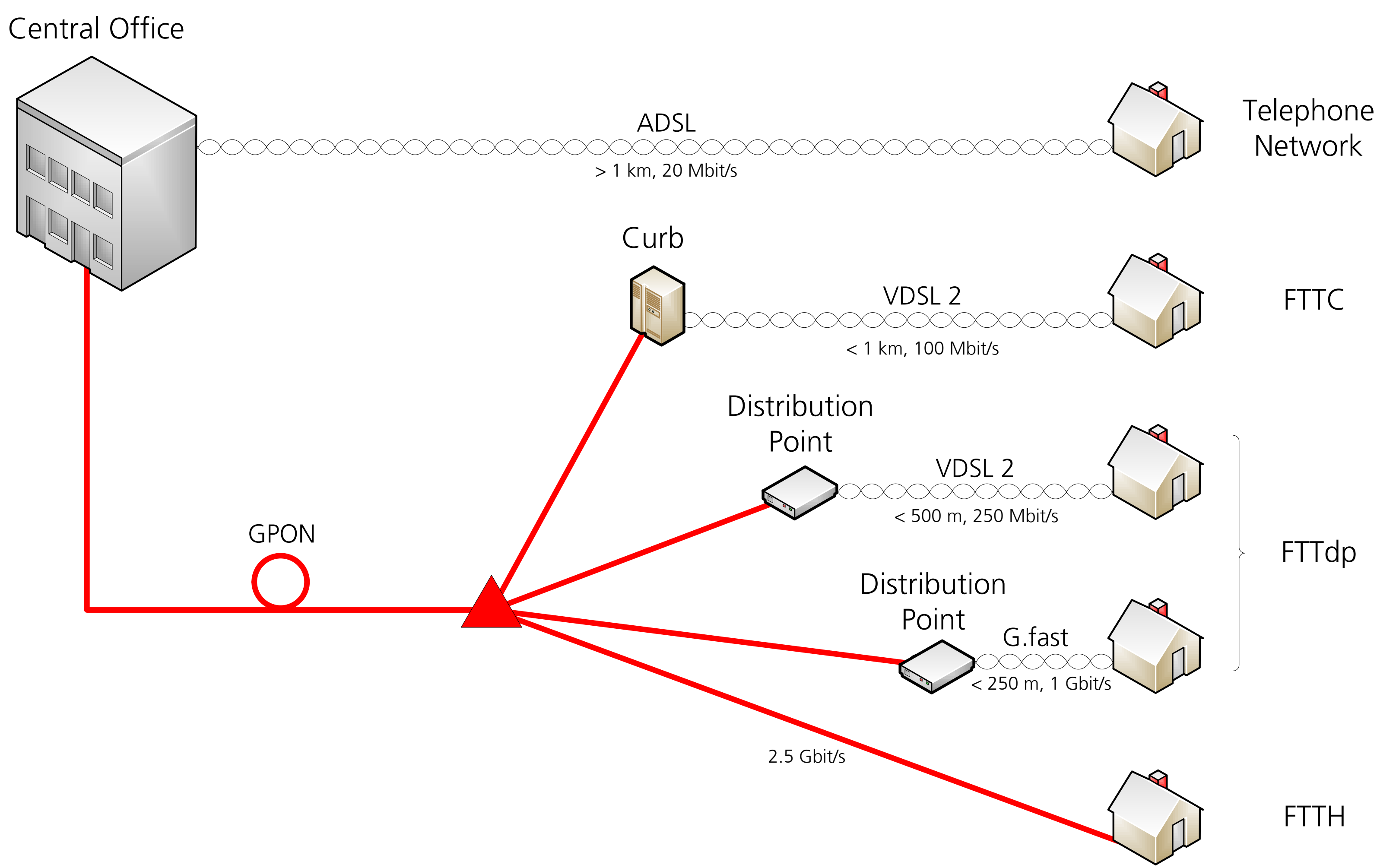
HYBRIDE BREITBANDTECHNOLOGIEN AUS SICHT DER FORSCHUNG

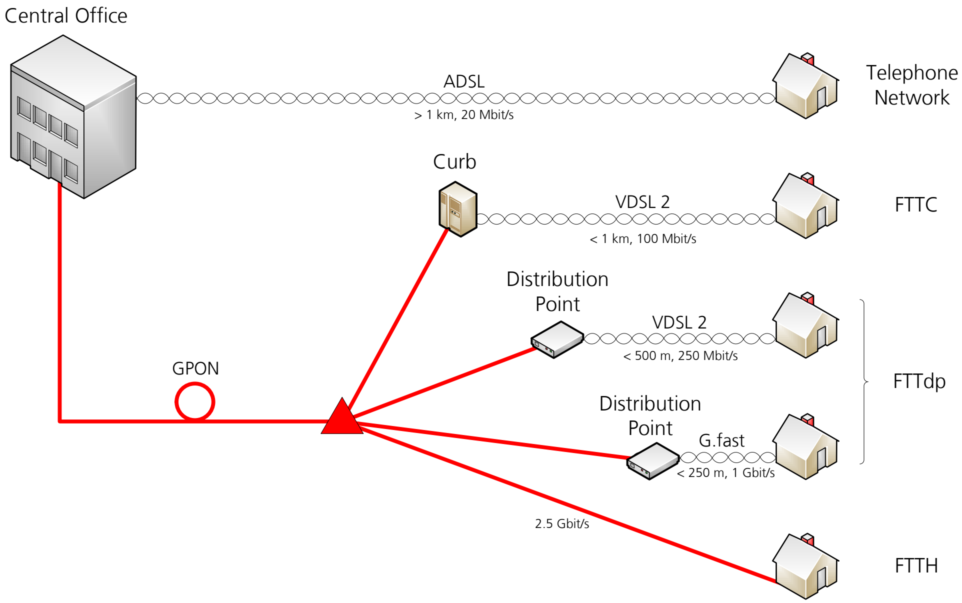
Labortests, Simulationen und Praxisrelevanz

Fraunhofer
ESK

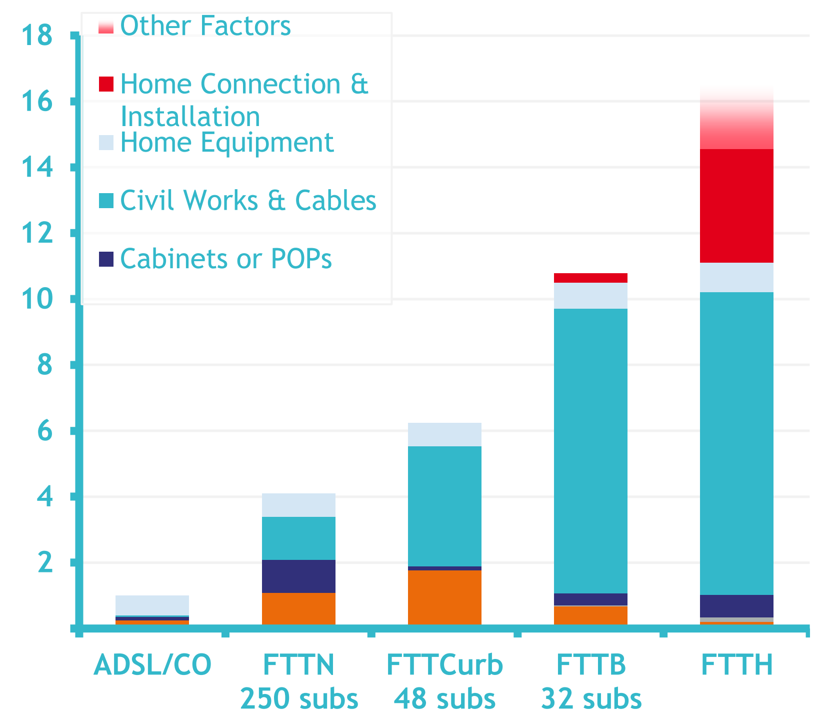
Evolution des Zugangsnetzes – Hybride Lösungen



Warum hybride Lösungen?



Im wesentlichen eine Kostenfrage



[Quelle: Alcatel Lucent, IT-Gipfel 2015 – Smart Home]

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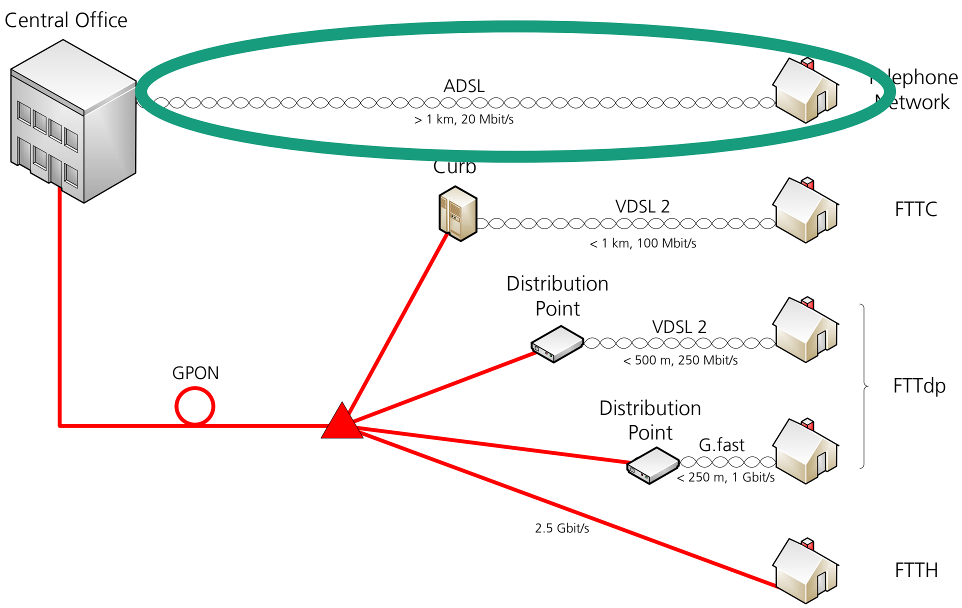
Warum hybride Lösungen?



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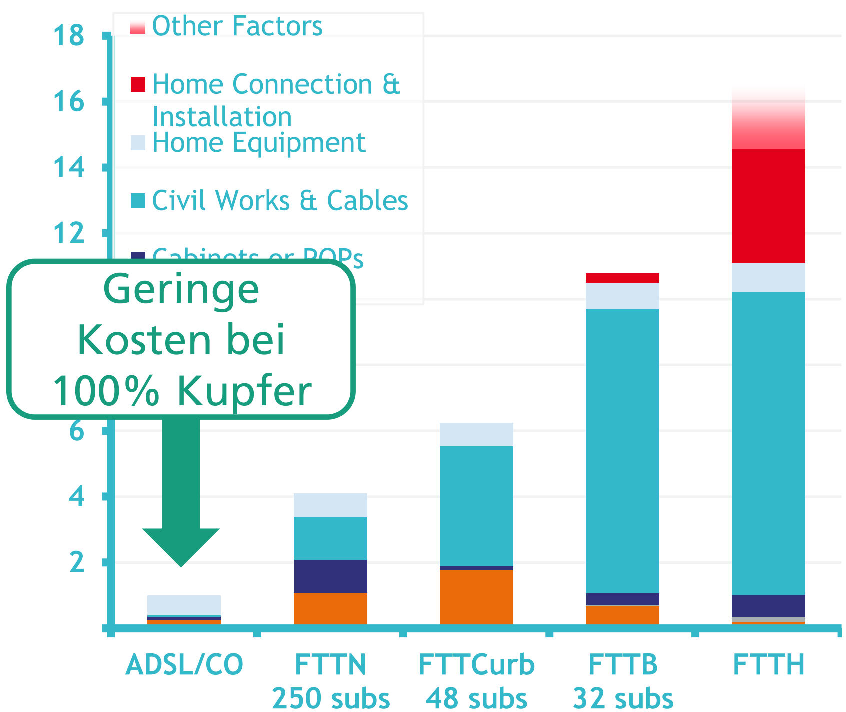

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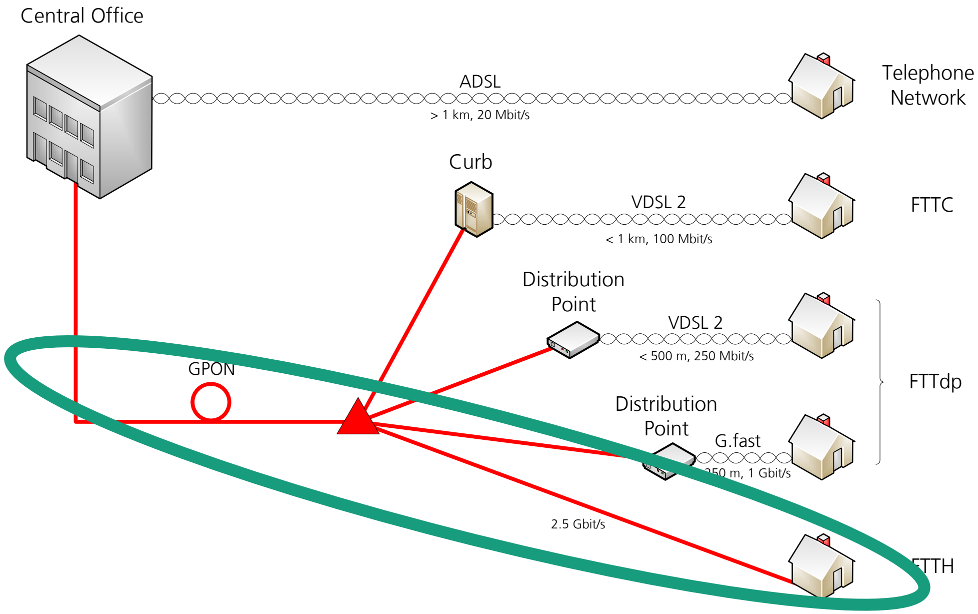

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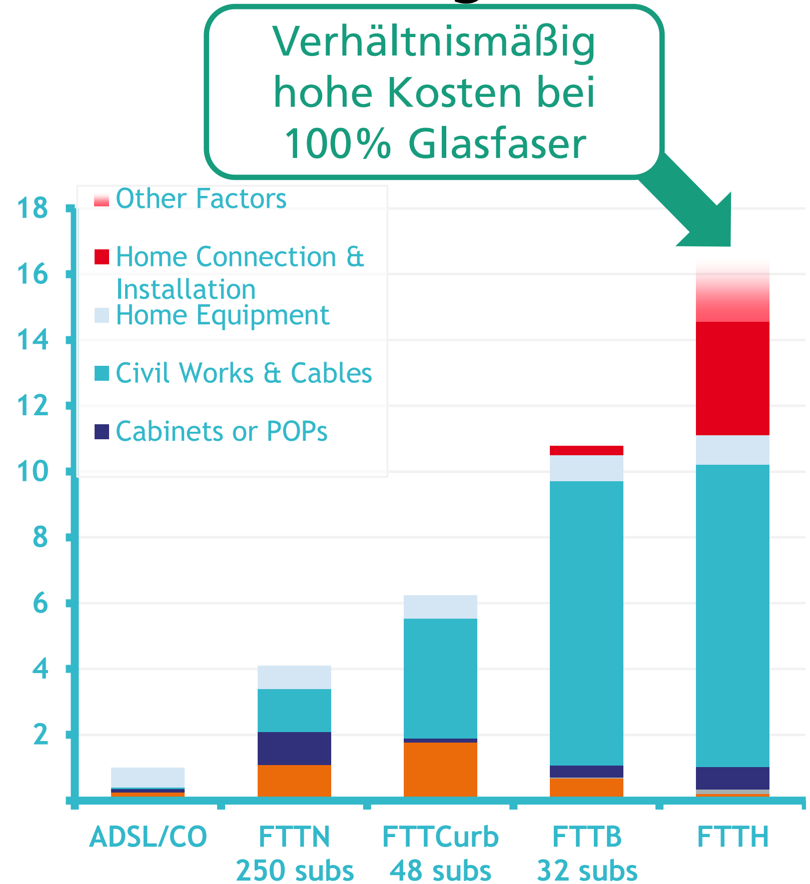

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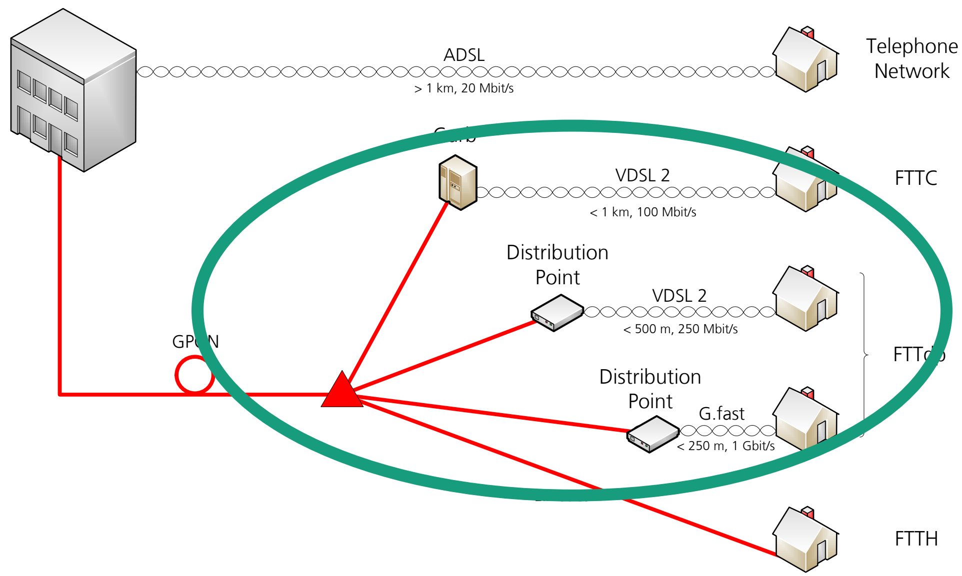
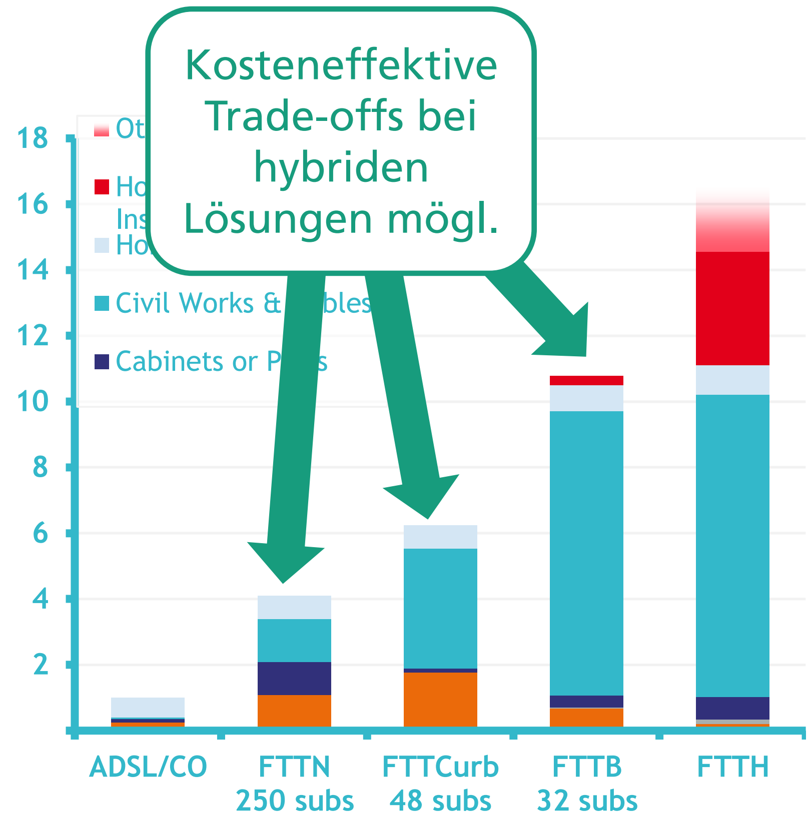


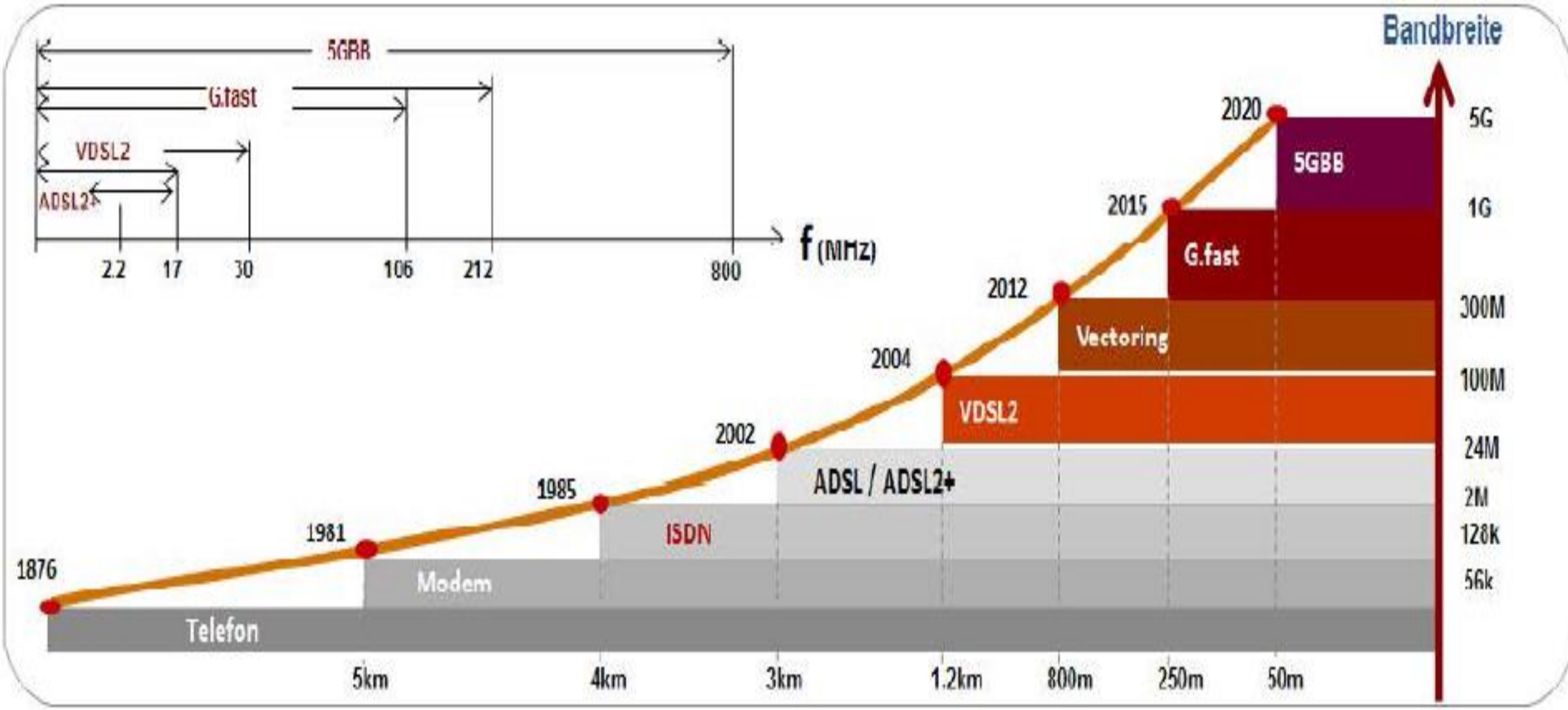
Im wesentlichen eine Kostenfrage



[Quelle: Alcatel Lucent, IT-Gipfel 2015 – Smart Home]

Fraunhofer ESK

Hybride Lösungen - Datenraten ausreichend?



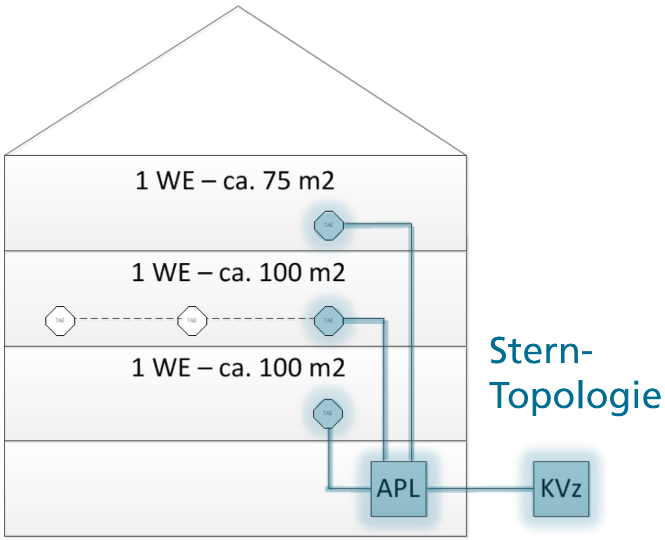
[Quelle: Huawei, IT Gipfel der Bundesregierung Working Group 8]

Übertragungseigenschaften verstehen

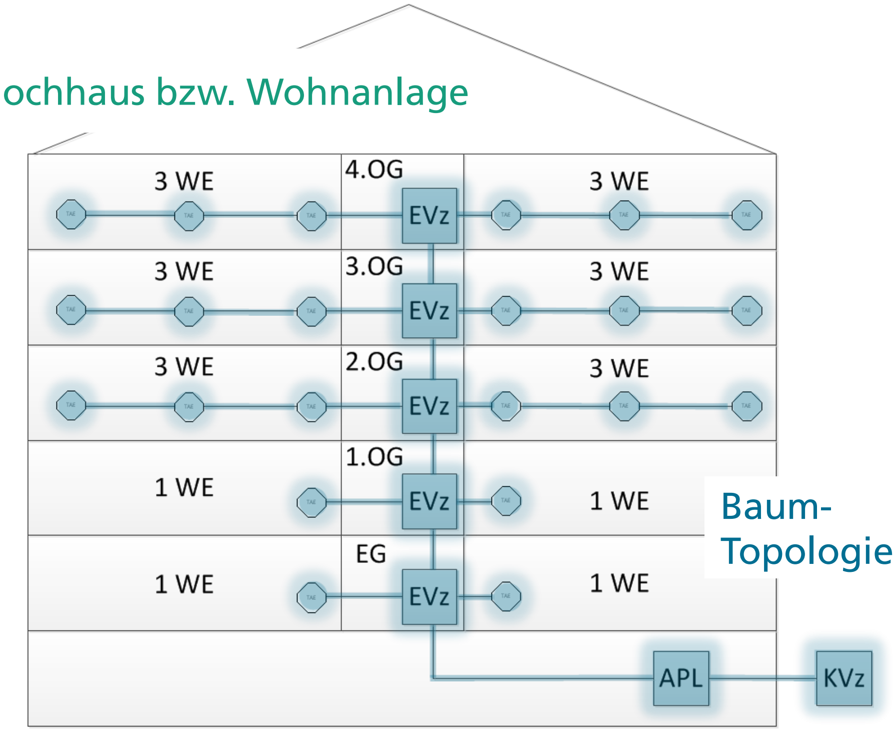
Bestandsaufnahme in DE – Typische Inhaus-Szenarien

- Zwei wesentliche Gebäudeklassen:

Ein-, Zwei- und kl. Mehrfamilienhaus



Hochhaus bzw. Wohnanlage



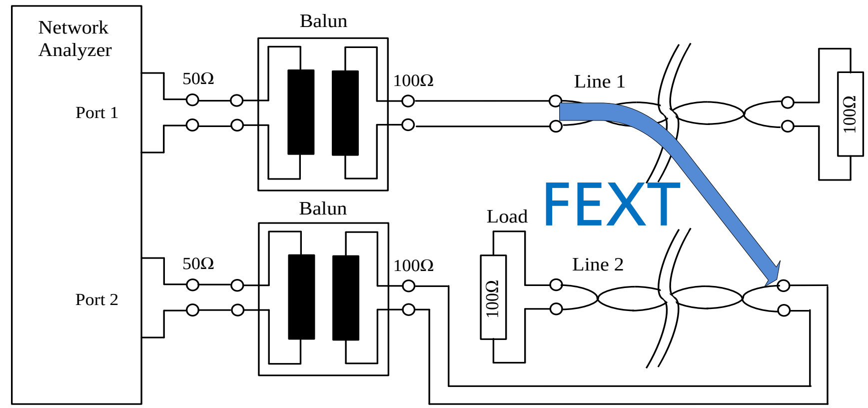
- Typische Kabel im Haus:

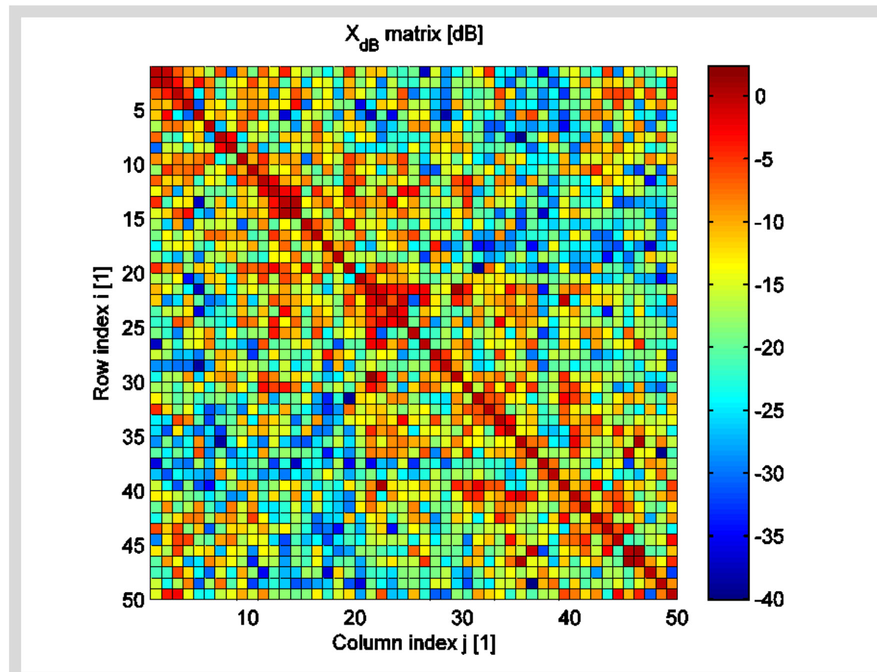
Zeitpunkt der Inhouse-Installation	Verwendetet Kabeltypen
bis 1990	Viererseil
von 1990 bis 2000	J-YY, J-Y(St)Y 2*2*0.6
ab 2000	J-Y(St)Y 2*2*0.6

Zeitpunkt der Inhouse-Installation	Verwendetet Kabeltypen
bis 1990	Viererseil (im Leerrohr)
von 1990 bis 2000	J-YY, J-Y(St)Y 20*2*0.6
ab 2000	CAT5, J-Y(St)Y 20*2*0.6

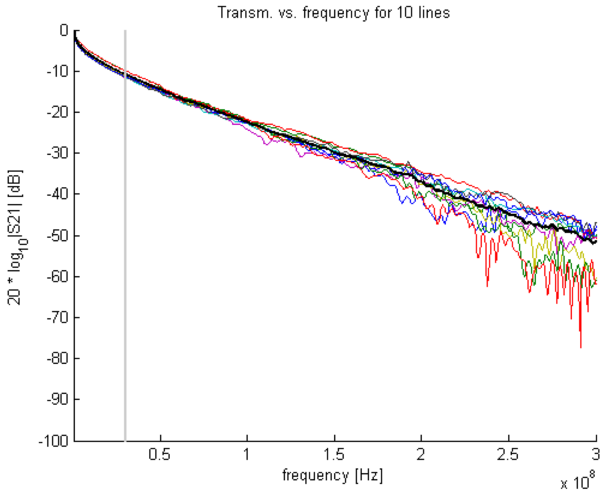
Fraunhofer ESK

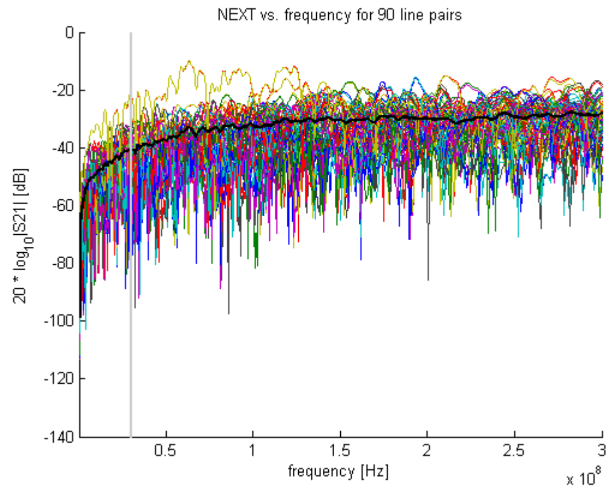
Übertragungseigenschaften bestimmen - Kabelmessungen

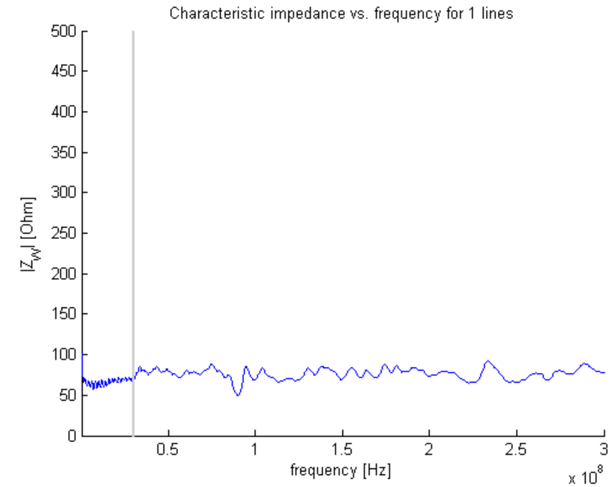


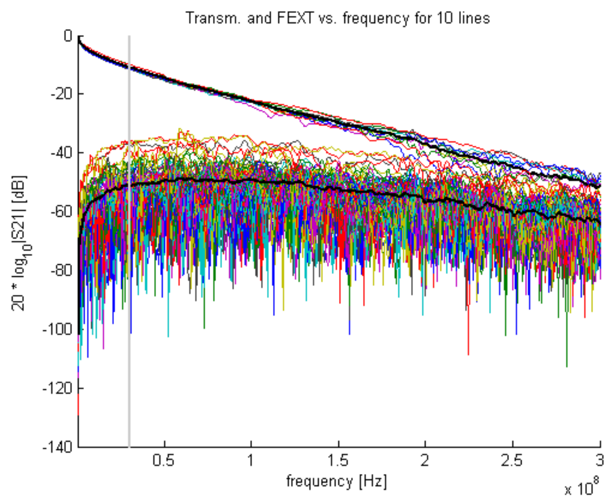


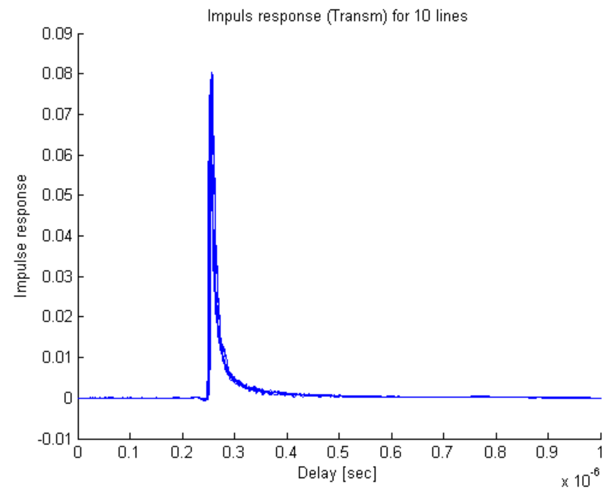
Kompletter Datensatz einer Leitung -> Modellbildung







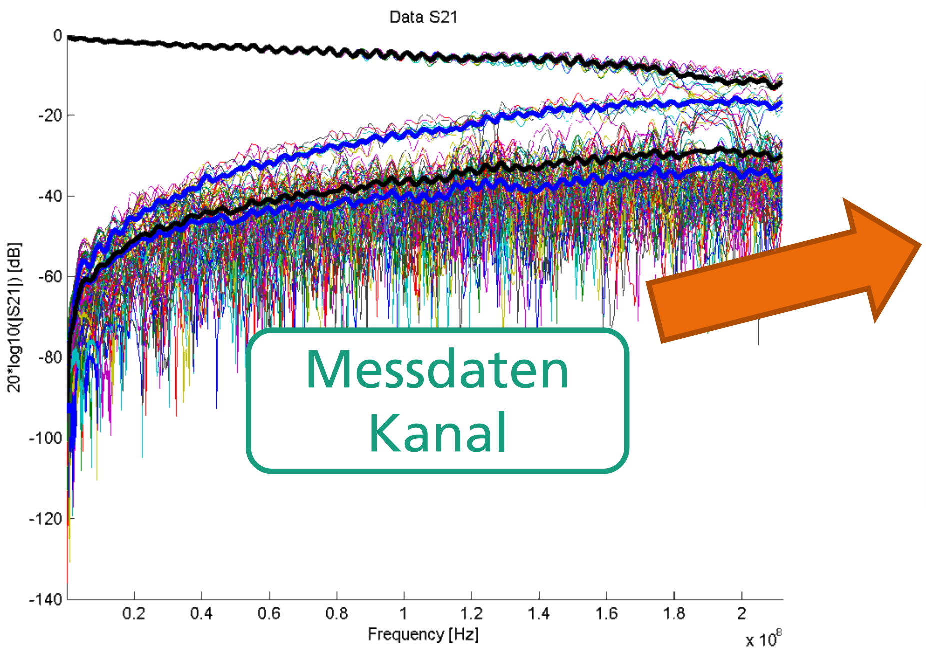




J-Y(St)Y 10*2*0.6, 50m

Fraunhofer ESK

Mit neuen Modellen näher an die Realität



SISO-Modell

$[Z_s, Y_p] = Model\ (Z_{0\infty}, \eta_{VF}, R_{s0}, q_L, q_H, q_c, q_x, q_y, \phi, f_d)$

$$Z_s(j\omega) = j\omega \cdot L_{s\infty} + R_{s0} \times \left(1 - q_s \cdot q_x + sqrt\left(q_s^2 \cdot q_x^2 + 2 \cdot \frac{j\omega}{\omega_s} \cdot \left(\frac{q_s^2 + j\omega/\omega_s \cdot q_y}{q_s^2/q_x + j\omega/\omega_s \cdot q_y}\right)\right)\right)$$

$$Y_p(j\omega) = j\omega \cdot C_{p0} \times (1 - q_c) \times \left(1 + \frac{j\omega}{\omega_d}\right)^{-2\cdot\phi/\pi} + j\omega \cdot C_{p0} \times q_c$$

$$L_{s\infty} = \frac{1}{\eta_{VF} \cdot c_0} \times Z_{0\infty}$$

$$C_{p0} = \frac{1}{\eta_{VF} \cdot c_0} \times \frac{1}{Z_{0\infty}}$$

$$q_s = \frac{1}{q_H^2 \cdot q_L}$$

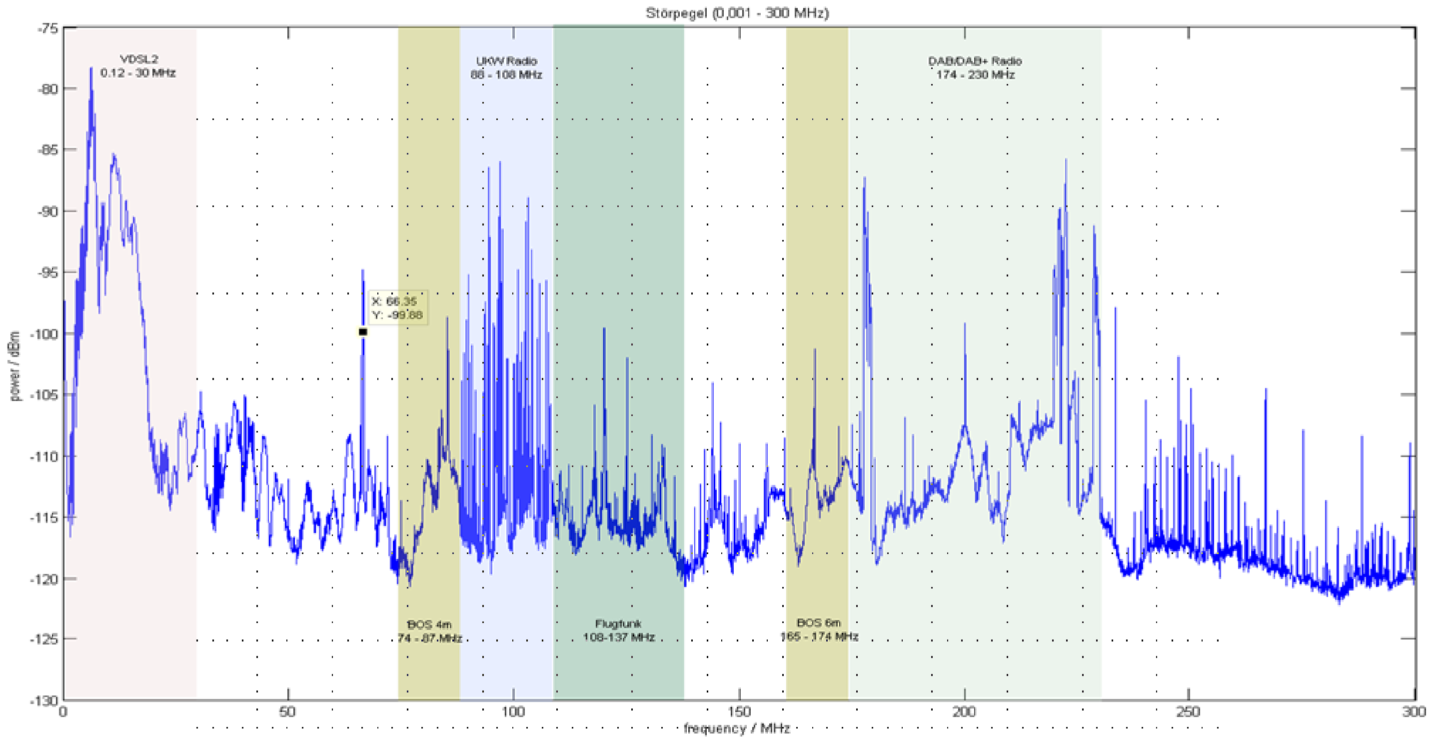
$$\omega_s = q_H^2 \cdot \omega_{s0} = q_H^2 \cdot \left(\frac{4\pi \cdot R_{s0}}{\mu_0}\right)$$

$$\omega_d = 2\pi \cdot f_d$$

$c_0 = 3 \cdot 10^8$ [m/s]

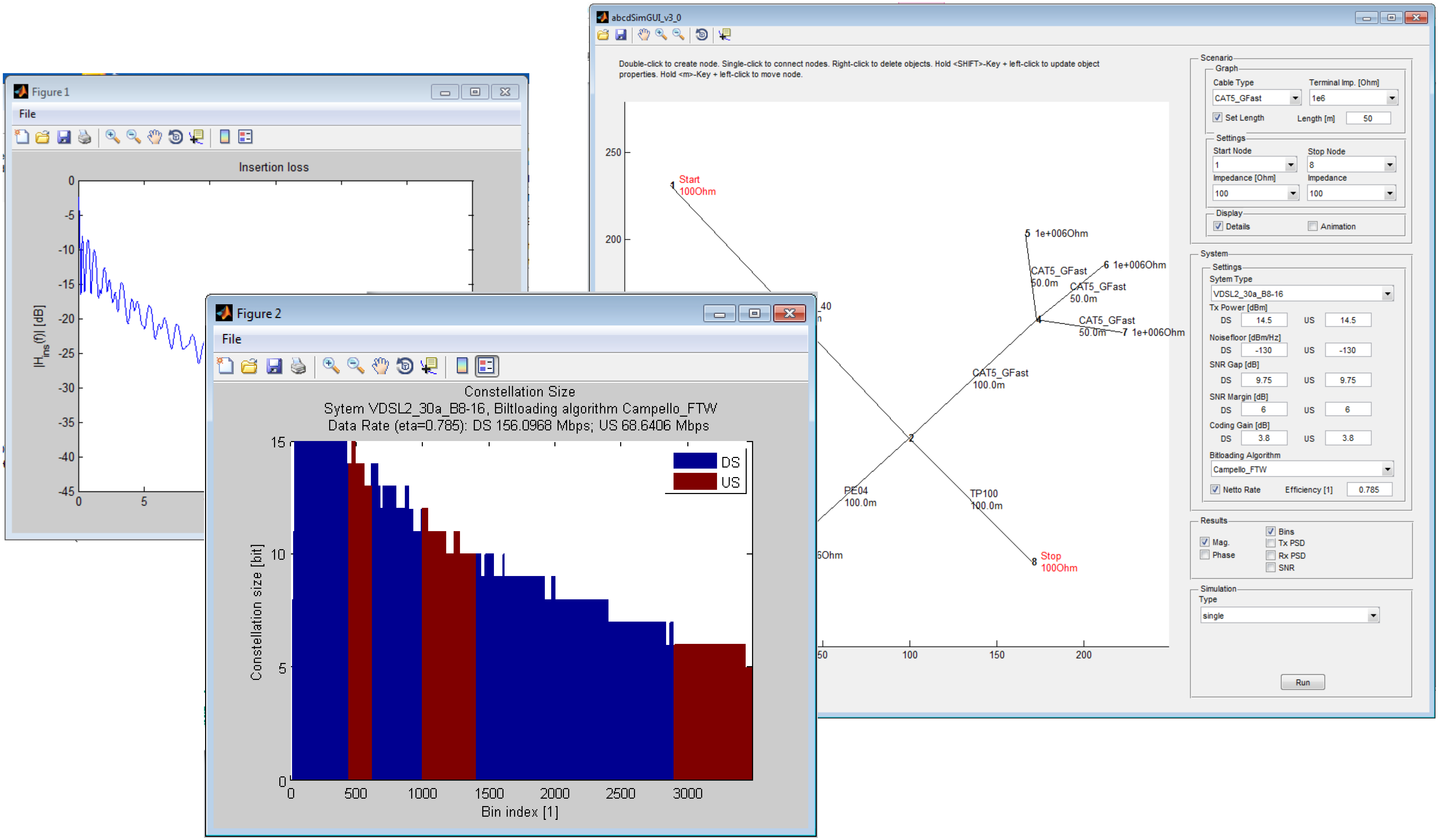
$\mu_0 = 4\pi \cdot 10^{-7}$ [H/m].

Übertragungseigenschaften bestimmen - Rauschmessungen

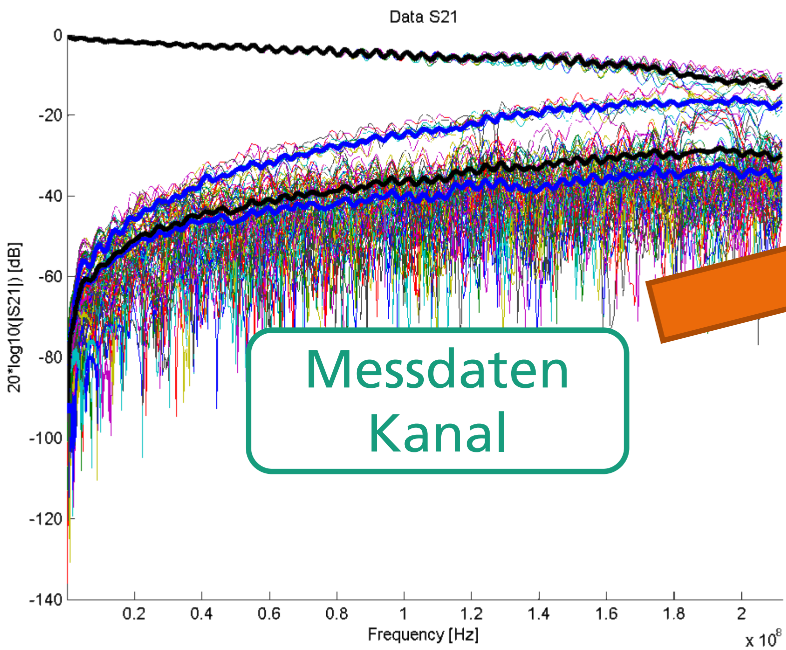


Modelle und Simulationen zur Nachbildung der Realität

Computer Simulationen für die Analyse - Erste Schritte



Mit neuen Modellen näher an die Realität



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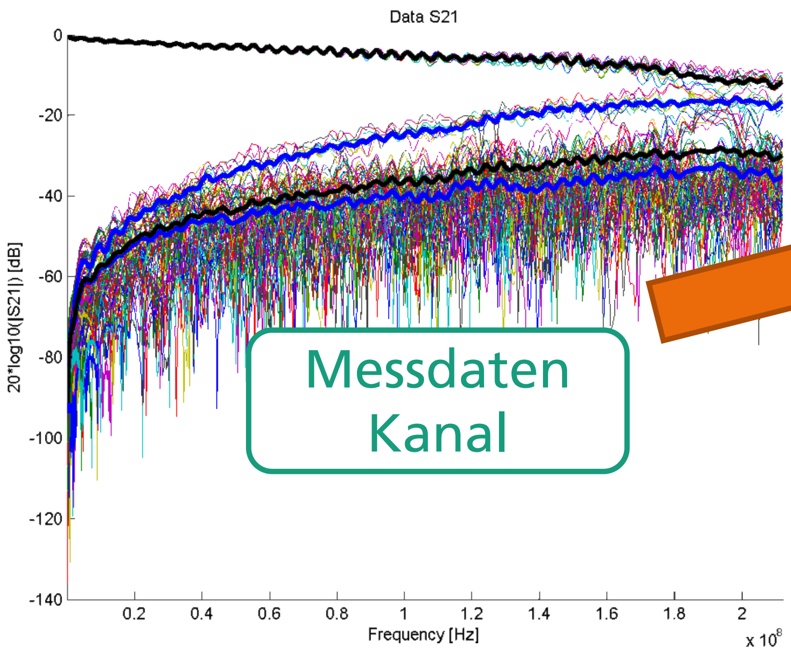
Mit neuen Modellen näher an die Realität



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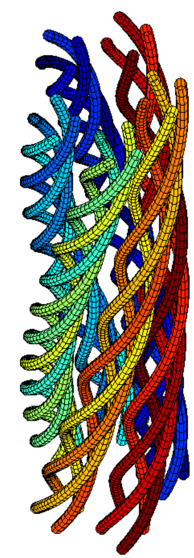
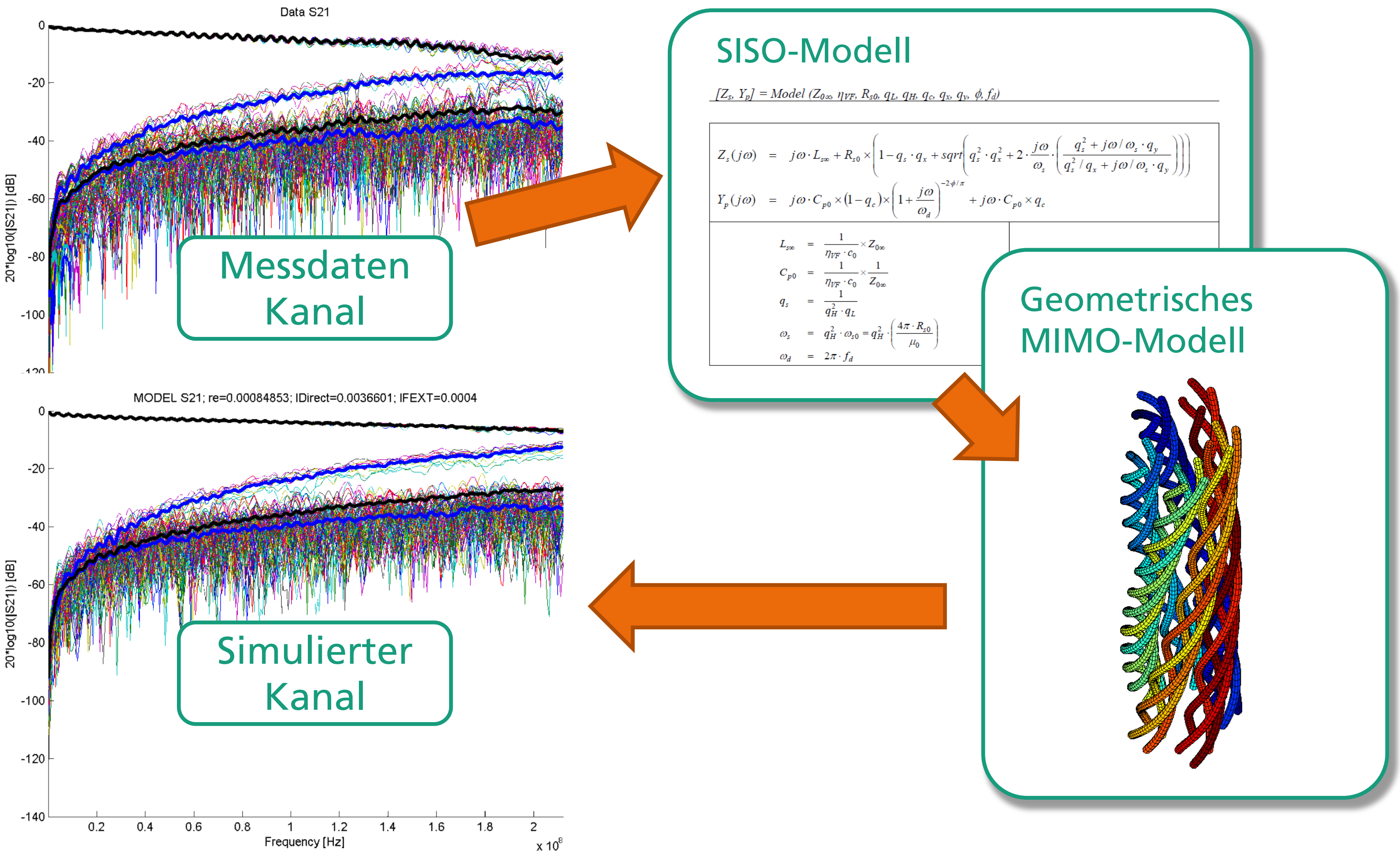
Geometrisches MIMO-Modell



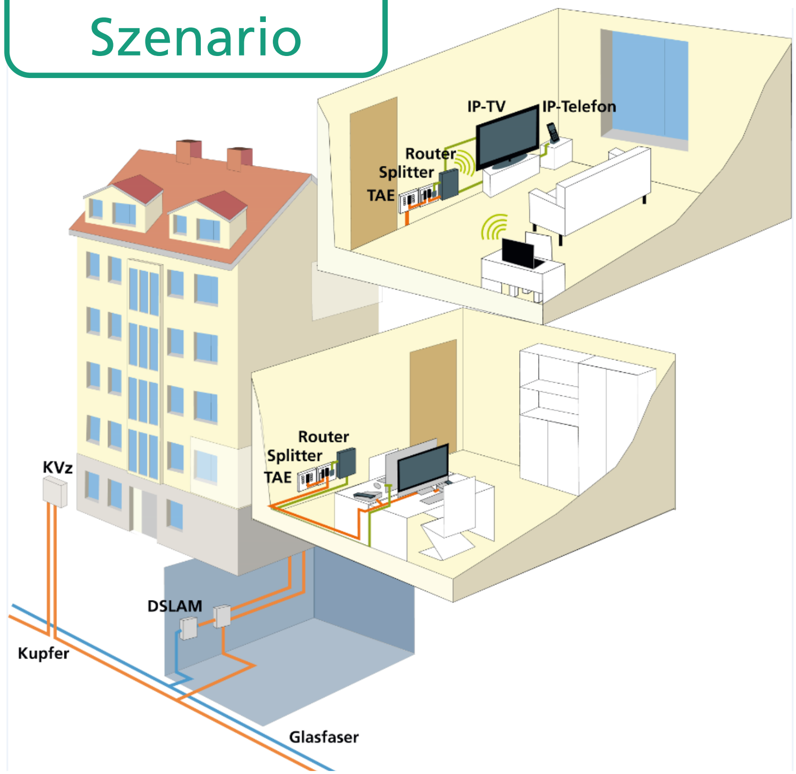
Mit neuen Modellen näher an die Realität



Anwendungsfälle

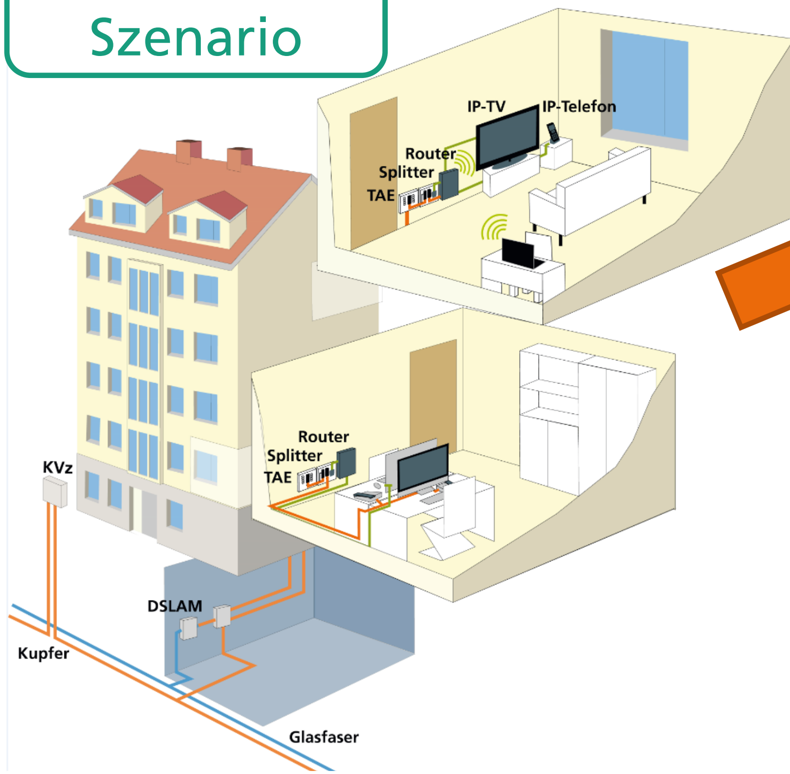
Realistische Szenarien für praxisnahe Ergebnisse

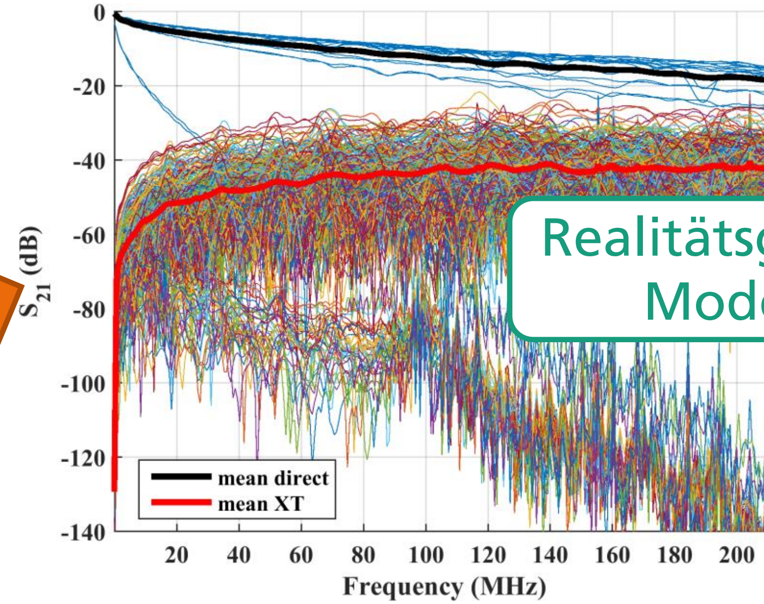
Realistisches Szenario



Realistische Szenarien für praxisnahe Ergebnisse

Realistisches Szenario

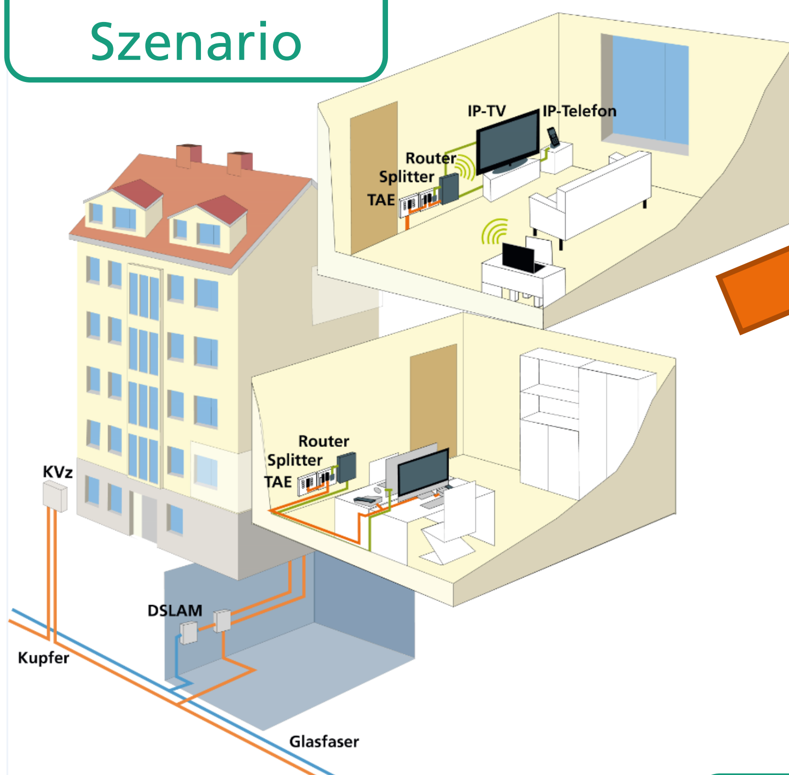


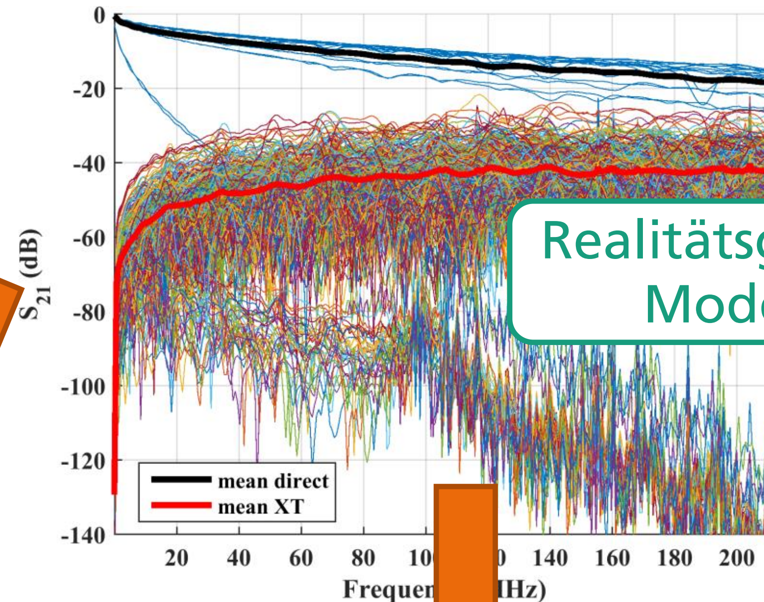


Realitätsgetreue Modelle

Realistische Szenarien für praxisnahe Ergebnisse

Realistisches Szenario





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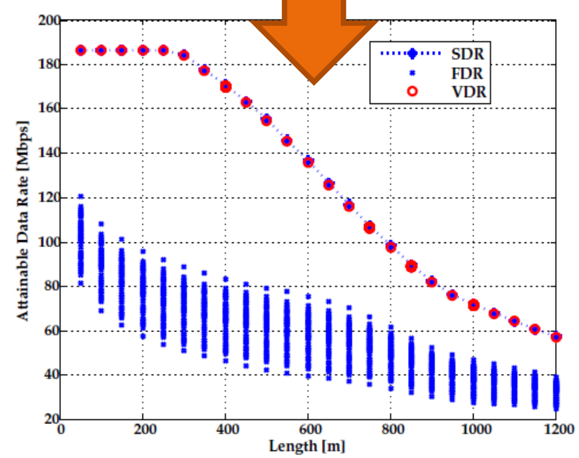
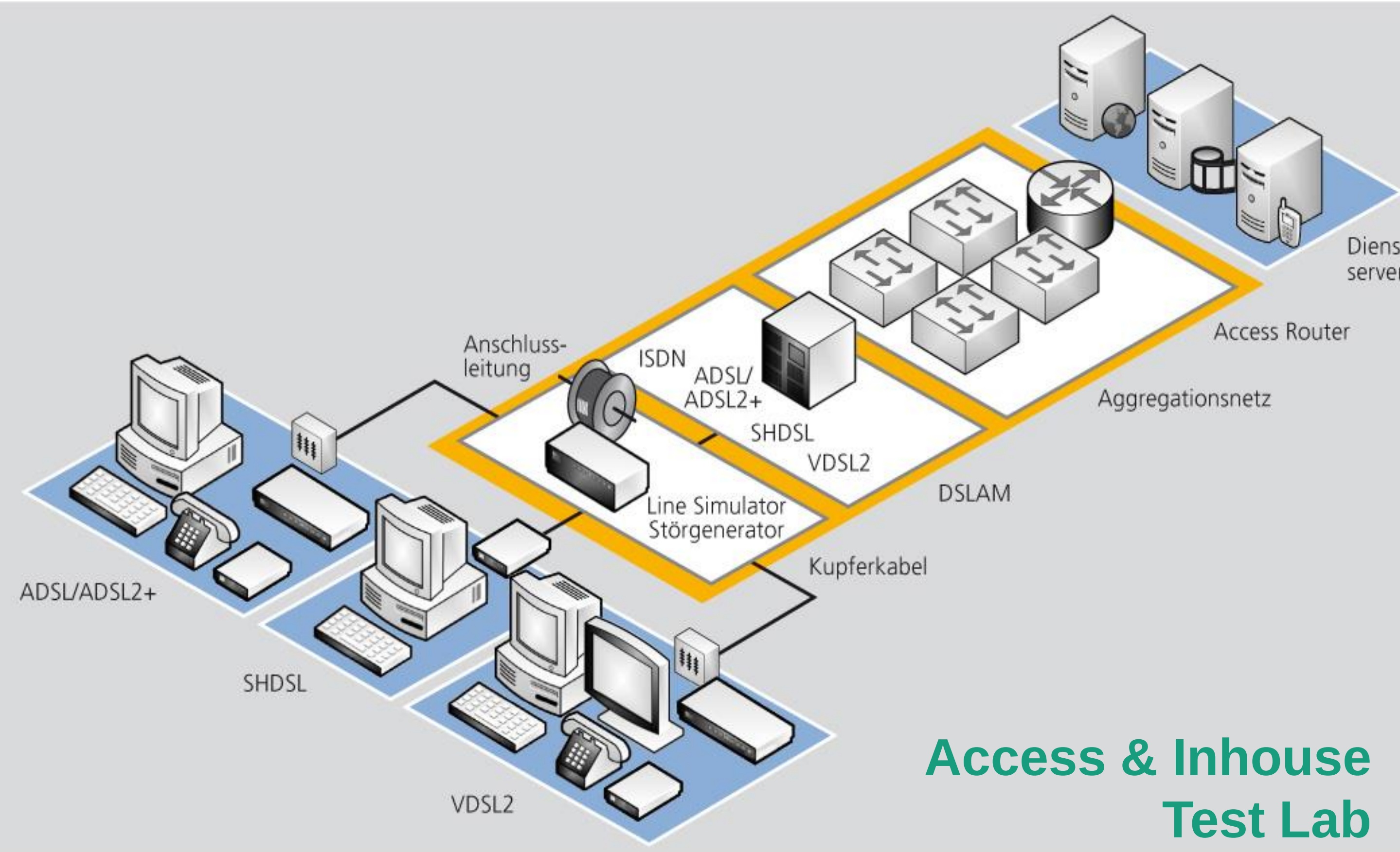


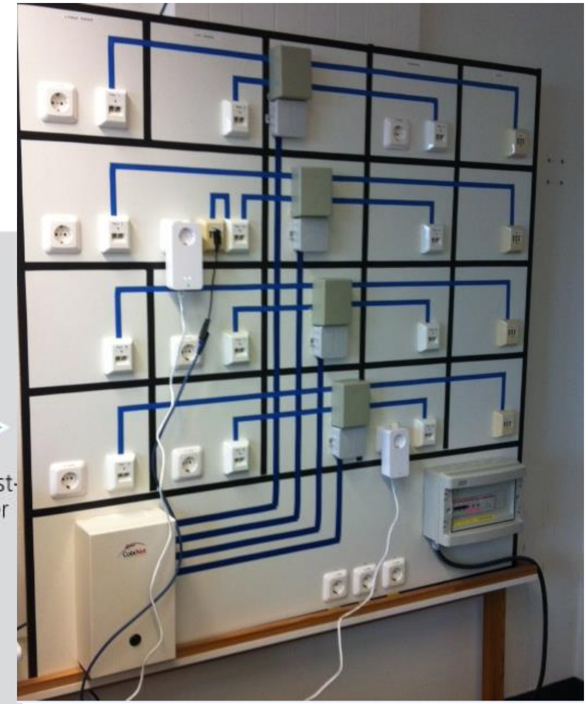
Praxisnahe Ergebnisse

Erprobung und Test

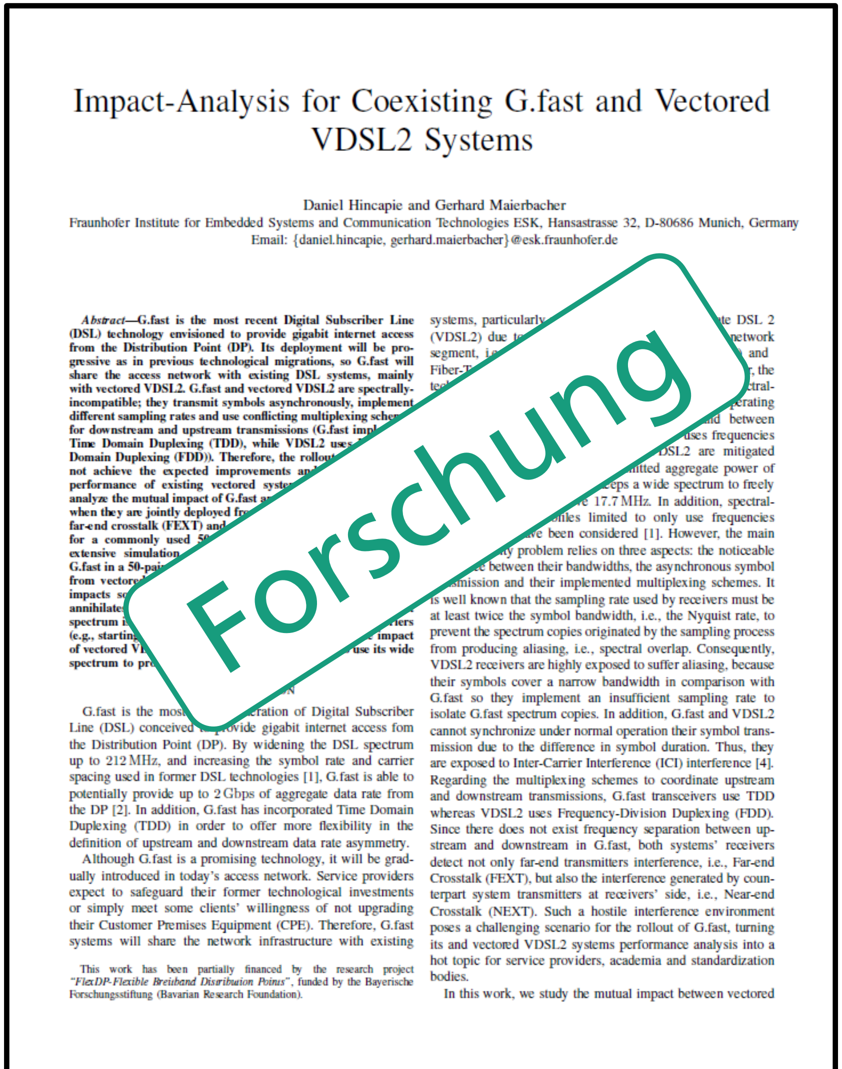
Labor für Erprobung und Test



Access & Inhouse Test Lab



Koexistenz – Ein aktuelles Problem



Impact-Analysis for Coexisting G.fast and Vectored VDSL2 Systems

Daniel Hincapie and Gerhard Maierbacher
Fraunhofer Institute for Embedded Systems and Communication Technologies ESK, Hansastrasse 32, D-80686 Munich, Germany
Email: {daniel.hincapie, gerhard.maierbacher}@esk.fraunhofer.de

***Abstract*—G.fast is the most recent Digital Subscriber Line (DSL) technology envisioned to provide gigabit internet access from the Distribution Point (DP). Its deployment will be progressive as in previous technological migrations, so G.fast will share the access network with existing DSL systems, mainly with vectored VDSL2. G.fast and vectored VDSL2 are spectrally-incompatible; they transmit symbols asynchronously, implement different sampling rates and use conflicting multiplexing schem
for downstream and upstream transmissions (G.fast impl
Time Domain Duplexing (TDD), while VDSL2 uses
Domain Duplexing (FDD)). Therefore, the rollout
not achieve the expected improvements an
performance of existing vectored syste
analyze the mutual impact of G.fast a
when they are jointly deployed fr
far-end crosstalk (FEXT) and
for a commonly used 5
extensive simulation
G.fast in a 50-pai
from vectore
impacts s
annihilate
spectrum i
riers
(e.g., startin
impact
of vectored V
use its wide
spectrum to pr**

N

G.fast is the mos
eration of Digital Subscriber Line (DSL) conceived
provide gigabit internet access fom the Distribution Point (DP). By widening the DSL spectrum up to 212 MHz, and increasing the symbol rate and carrier spacing used in former DSL technologies [1], G.fast is able to potentially provide up to 2 Gbps of aggregate data rate from the DP [2]. In addition, G.fast has incorporated Time Domain Duplexing (TDD) in order to offer more flexibility in the definition of upstream and downstream data rate asymmetry.

Although G.fast is a promising technology, it will be gradually introduced in today's access network. Service providers expect to safeguard their former technological investments or simply meet some clients' willingness of not upgrading their Customer Premises Equipment (CPE). Therefore, G.fast systems will share the network infrastructure with existing

systems, particularly
te DSL 2
(VDSL2) due t
network
segment, i.e
and
Fiber-T
, the
tec
ctral-
perating
d between
uses frequencies
DSL2 are mitigated
mitted aggregate power of
eeps a wide spectrum to freely
e 17.7 MHz. In addition, spectral-
ofiles limited to only use frequencies
ve been considered [1]. However, the main
ty problem relies on three aspects: the noticeable
e between their bandwidths, the asynchronous symbol
smission and their implemented multiplexing schemes. It is well known that the sampling rate used by receivers must be at least twice the symbol bandwidth, i.e., the Nyquist rate, to prevent the spectrum copies originated by the sampling process from producing aliasing, i.e., spectral overlap. Consequently, VDSL2 receivers are highly exposed to suffer aliasing, because their symbols cover a narrow bandwidth in comparison with G.fast so they implement an insufficient sampling rate to isolate G.fast spectrum copies. In addition, G.fast and VDSL2 cannot synchronize under normal operation their symbol transmission due to the difference in symbol duration. Thus, they are exposed to Inter-Carrier Interference (ICI) interference [4]. Regarding the multiplexing schemes to coordinate upstream and downstream transmissions, G.fast transceivers use TDD whereas VDSL2 uses Frequency-Division Duplexing (FDD). Since there does not exist frequency separation between upstream and downstream in G.fast, both systems' receivers detect not only far-end transmitters interference, i.e., Far-end Crosstalk (FEXT), but also the interference generated by counterpart system transmitters at receivers' side, i.e., Near-end Crosstalk (NEXT). Such a hostile interference environment poses a challenging scenario for the rollout of G.fast, turning its and vectored VDSL2 systems performance analysis into a hot topic for service providers, academia and standardization bodies.

In this work, we study the mutual impact between vectored

This work has been partially financed by the research project *"FlexDP-Flexible Breitband Distribuion Poins"*, funded by the Bayerische Forschungsstiftung (Bavarian Research Foundation).

Koexistenz – Ein aktuelles Problem

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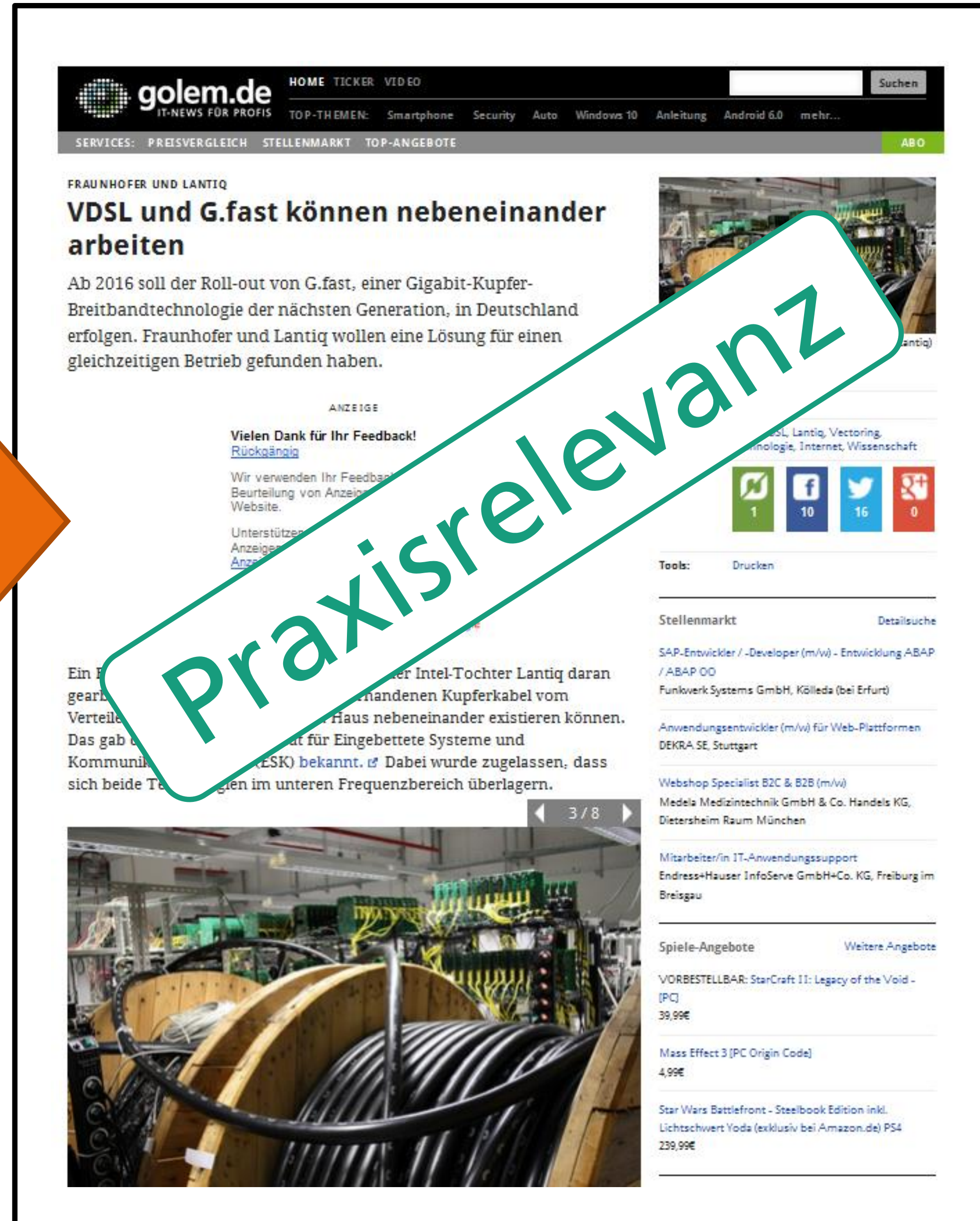
[illegible]ON

G.fast is the mos[illegible]eration of Digital Subscriber Line (DSL) conceived [illegible]rovide gigabit internet access fom the Distribution Point (DP). By widening the DSL spectrum up to 212 MHz, and increasing the symbol rate and carrier spacing used in former DSL technologies [1], G.fast is able to potentially provide up to 2 Gbps of aggregate data rate from the DP [2]. In addition, G.fast has incorporated Time Domain Duplexing (TDD) in order to offer more flexibility in the definition of upstream and downstream data rate asymmetry.

Although G.fast is a promising technology, it will be gradually introduced in today's access network. Service providers expect to safeguard their former technological investments or simply meet some clients' willingness of not upgrading their Customer Premises Equipment (CPE). Therefore, G.fast systems will share the network infrastructure with existing systems, particularly [illegible]te DSL 2 (VDSL2) due t[illegible] network segment, i.[illegible] and Fiber-T[illegible], the tec[illegible]ctral-[illegible]perating [illegible]d between [illegible] uses frequencies [illegible]DSL2 are mitigated [illegible]itted aggregate power of [illegible]eps a wide spectrum to freely [illegible]e 17.7 MHz. In addition, spectral-[illegible]ofiles limited to only use frequencies [illegible]ve been considered [1]. However, the main [illegible]ty problem relies on three aspects: the noticeable [illegible]e between their bandwidths, the asynchronous symbol [illegible]smission and their implemented multiplexing schemes. It is well known that the sampling rate used by receivers must be at least twice the symbol bandwidth, i.e., the Nyquist rate, to prevent the spectrum copies originated by the sampling process from producing aliasing, i.e., spectral overlap. Consequently, VDSL2 receivers are highly exposed to suffer aliasing, because their symbols cover a narrow bandwidth in comparison with G.fast so they implement an insufficient sampling rate to isolate G.fast spectrum copies. In addition, G.fast and VDSL2 cannot synchronize under normal operation their symbol transmission due to the difference in symbol duration. Thus, they are exposed to Inter-Carrier Interference (ICI) interference [4]. Regarding the multiplexing schemes to coordinate upstream and downstream transmissions, G.fast transceivers use TDD whereas VDSL2 uses Frequency-Division Duplexing (FDD). Since there does not exist frequency separation between upstream and downstream in G.fast, both systems' receivers detect not only far-end transmitters interference, i.e., Far-end Crosstalk (FEXT), but also the interference generated by counterpart system transmitters at receivers' side, i.e., Near-end Crosstalk (NEXT). Such a hostile interference environment poses a challenging scenario for the rollout of G.fast, turning its and vectored VDSL2 systems performance analysis into a hot topic for service providers, academia and standardization bodies.

In this work, we study the mutual impact between vectored

This work has been partially financed by the research project *"FlexDP-Flexible Breitband Distribution Points"*, funded by the Bayerische Forschungsstiftung (Bavarian Research Foundation).



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Ab 2016 soll der Roll-out von G.fast, einer Gigabit-Kupfer-Breitbandtechnologie der nächsten Generation, in Deutschland erfolgen. Fraunhofer und Lantiq wollen eine Lösung für einen gleichzeitigen Betrieb gefunden haben.

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Vielen Dank für Ihr Feedback!
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Unterstütze[illegible] Anzeige[illegible] Anz[illegible]

Ein [illegible]er Intel-Tochter Lantiq daran gear[illegible]handenen Kupferkabel vom Verteile[illegible] Haus nebeneinander existieren können. Das gab [illegible]t für Eingebettete Systeme und Kommunik[illegible](ESK) bekannt. Dabei wurde zugelassen, dass sich beide Te[illegible]gien im unteren Frequenzbereich überlagern.

3 / 8

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VIELEN DANK!

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