



My experience as research influencer on YouTube and social media

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1. Scientific papers

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2. Teaching material

Making Cell-Free Massive MIMO Competitive With MMSE Processing and Centralized Implementation

Emil Björnson[✉], Senior Member, IEEE, and Luca Sanguinetti[✉], Senior Member, IEEE

Abstract—Cell-free Massive MIMO is considered as a promising technology for satisfying the increasing number of users and the need for higher spectral efficiency. The idea is to let many distributed access points (APs) communicate with all users in the network, possibly by using joint coherent signal processing. The aim of this paper is to provide the first comprehensive analysis of this technology under different degrees of cooperation among the APs. Particularly, the uplink spectral efficiencies of four different cell-free implementations are analyzed, with spatially correlated fading and arbitrary linear processing. It turns out that it is possible to outperform conventional Cellular Massive MIMO and small cell networks by a wide margin using generalized linear minimum-mean-square error (MMSE) combining. This is in sharp contrast to the existing literature, which advocates for maximum-ratio combining. Also, we show that a centralized implementation with optimal MMSE processing not only maximizes the SE but largely reduces the fronthaul signaling compared to the standard distributed approach. This makes it the preferred way to operate Cell-free Massive MIMO networks. Non-linear decoding is also investigated and shown to give negligible improvements.

Index Terms—Beyond 5G MIMO, cell-free massive MIMO, cellular massive MIMO, uplink, AP cooperation, MMSE processing, fronthaul signaling, non-linear decoding, small-cell networks.

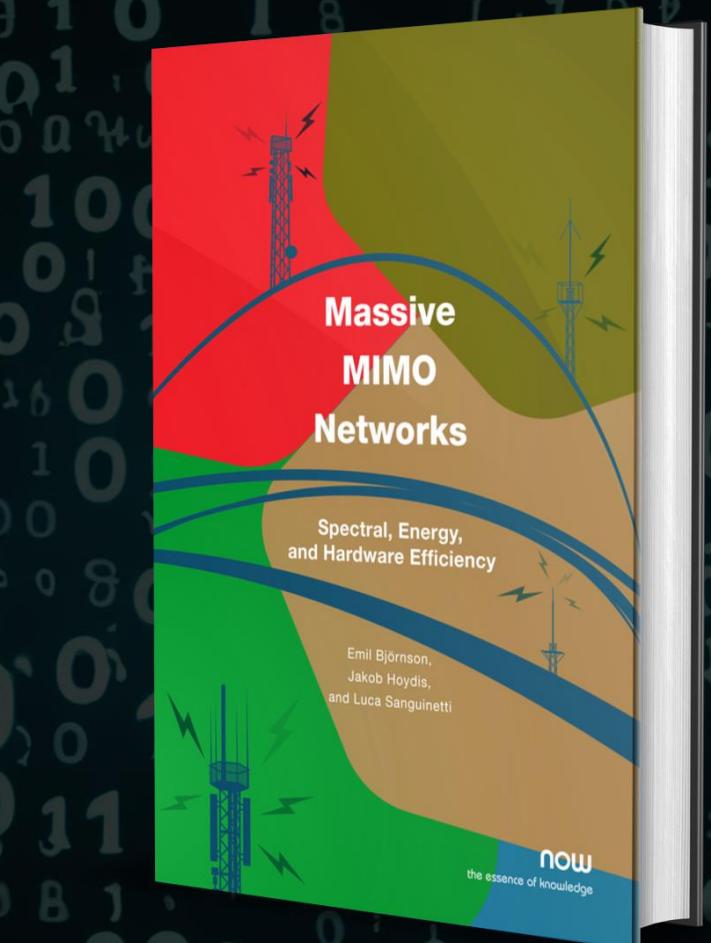
I. INTRODUCTION

THE traditional way to cover a large geographical area with wireless communication services uses the cellular network topology in Fig. 1(a), where each base station (BS) serves an exclusive set of user equipments (UEs) [2]. This network topology has been utilized for many decades and the spectral efficiency (SE) has been gradually improved by reducing the cell sizes and applying more advanced signal processing schemes for interference mitigation [3].

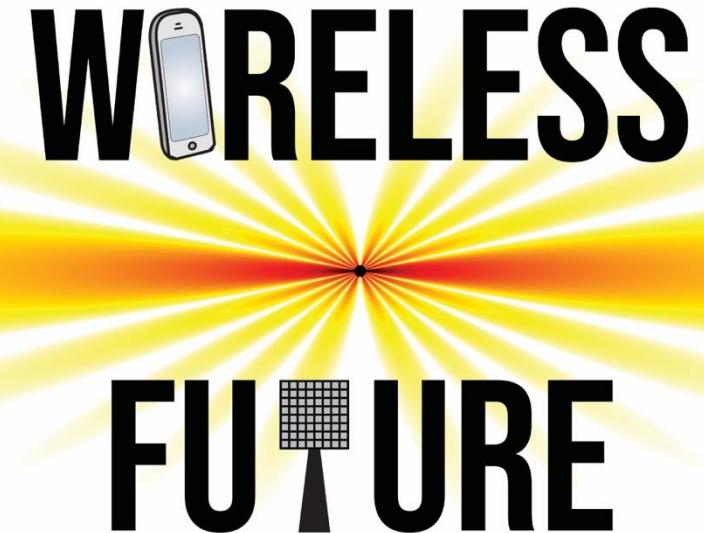
Recently, massive multiple-input multiple-output (mMIMO) has become the key 5G physical-layer technology [4]–[7].

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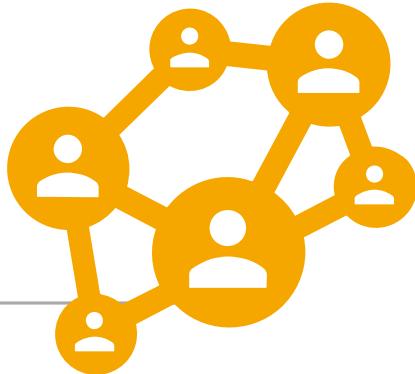
A. Motivation



3. Social media



Social media changes how we communicate



One-directional
news and information



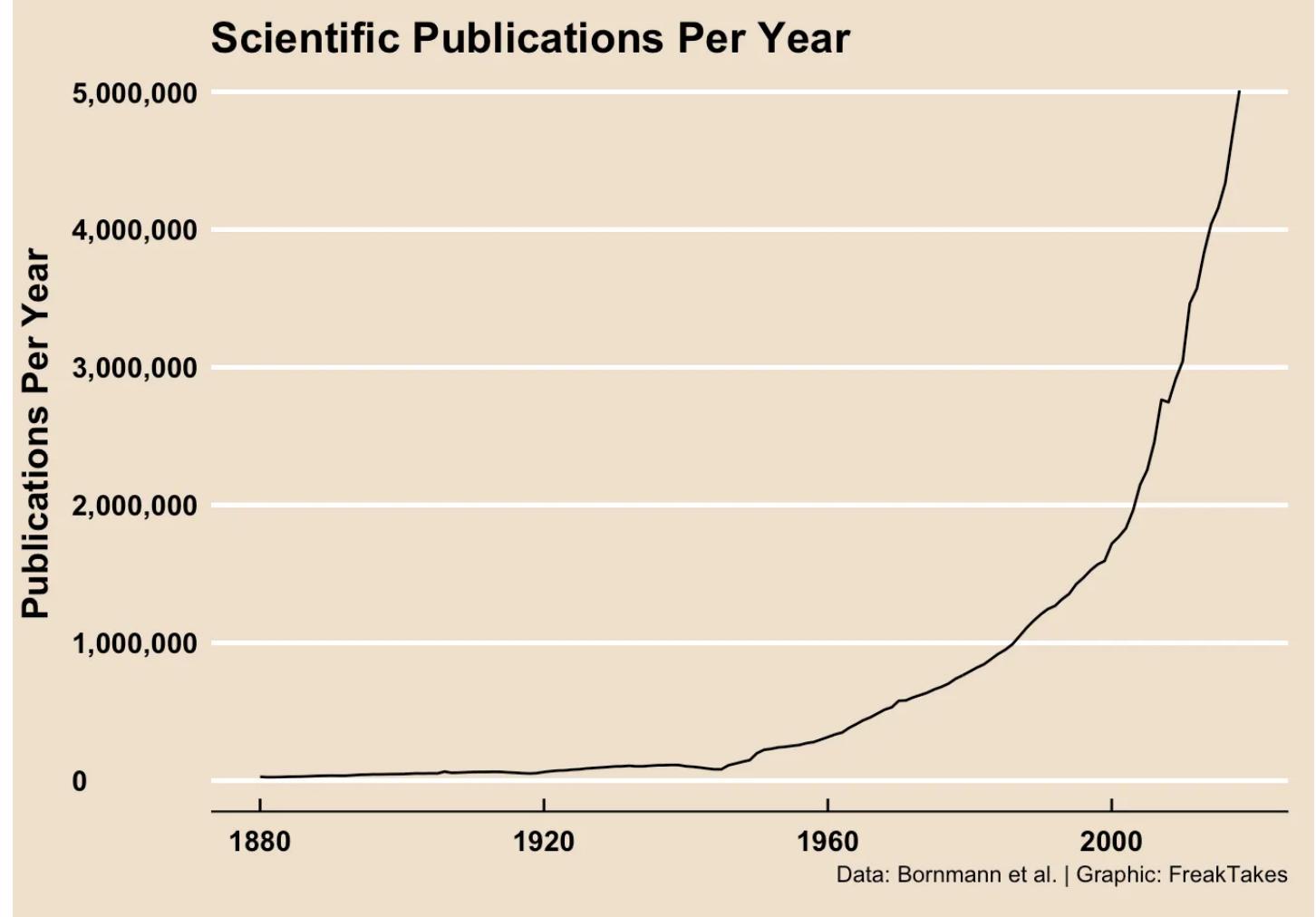
Instant interactions
between people

How will this change the research community?

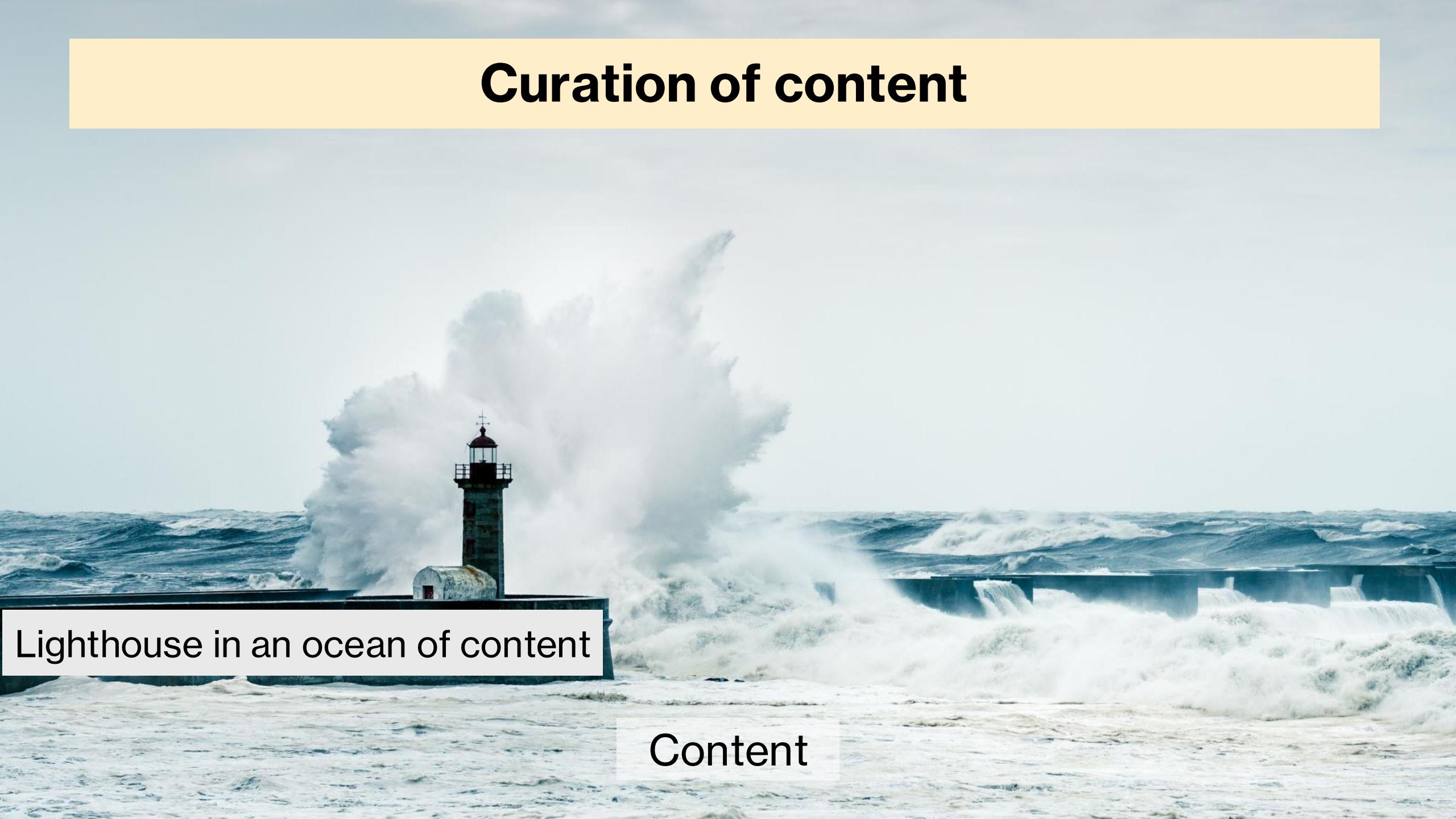


Explosion of scientific content

Is the information content growing this fast?



Curation of content

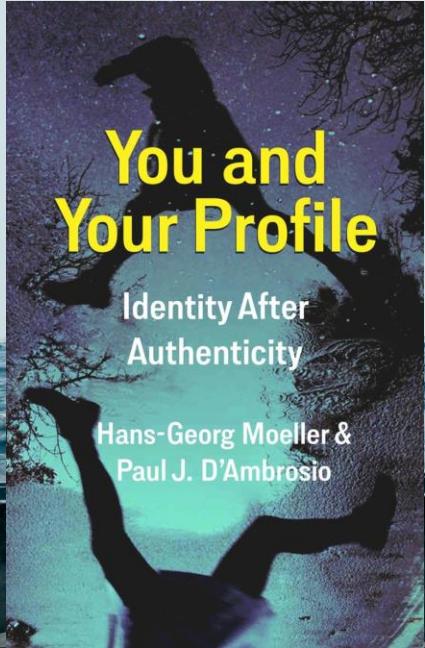
A photograph of a lighthouse standing on a dark, rocky pier extending into a turbulent sea. Large, white-capped waves are crashing against the pier's end, sending up plumes of spray. The sky is overcast and grey. In the top right corner of the slide, there is a solid yellow rectangular area.

Lighthouse in an ocean of content

Content

Age of Profilicity: Curation of yourself

- From: “Be yourself”
- To: Curate others’ perceptions of you



“We present ourselves and encounter others through profiles. A profile shows us not as we are seen directly but how we are perceived by a broader public. As we observe how others observe us, we calibrate our self-presentation accordingly.”

The LinkedIn Effect

Real life



Jane
Used ChatGPT
a few times (twice)



Carlos
Marketer
(team of 1)



Amer
Struggling Freelancer



Hannah
Made \$1000 in a day
(once)

LinkedIn Alter Ego



Jane
AI Evangelist & Expert.
ChatGPT + Bard + Every
other AI tool (that pays me)
to 10x productivity.



Carlos
Head of Marketing, Project
Manager, SEO & ABC & DEF
Expert. Passionate team guiding
spirit & Thought leader



Amer
CEO @Amer Industries.
Entrepreneur. Building the
future. Forbes 1000u1000.



Hannah
How to make \$365k/year
by working <10 min/day.
Buy my course only \$9999
(Total sold: 0)

Genuine pretender:
Not faking but striving for elevation

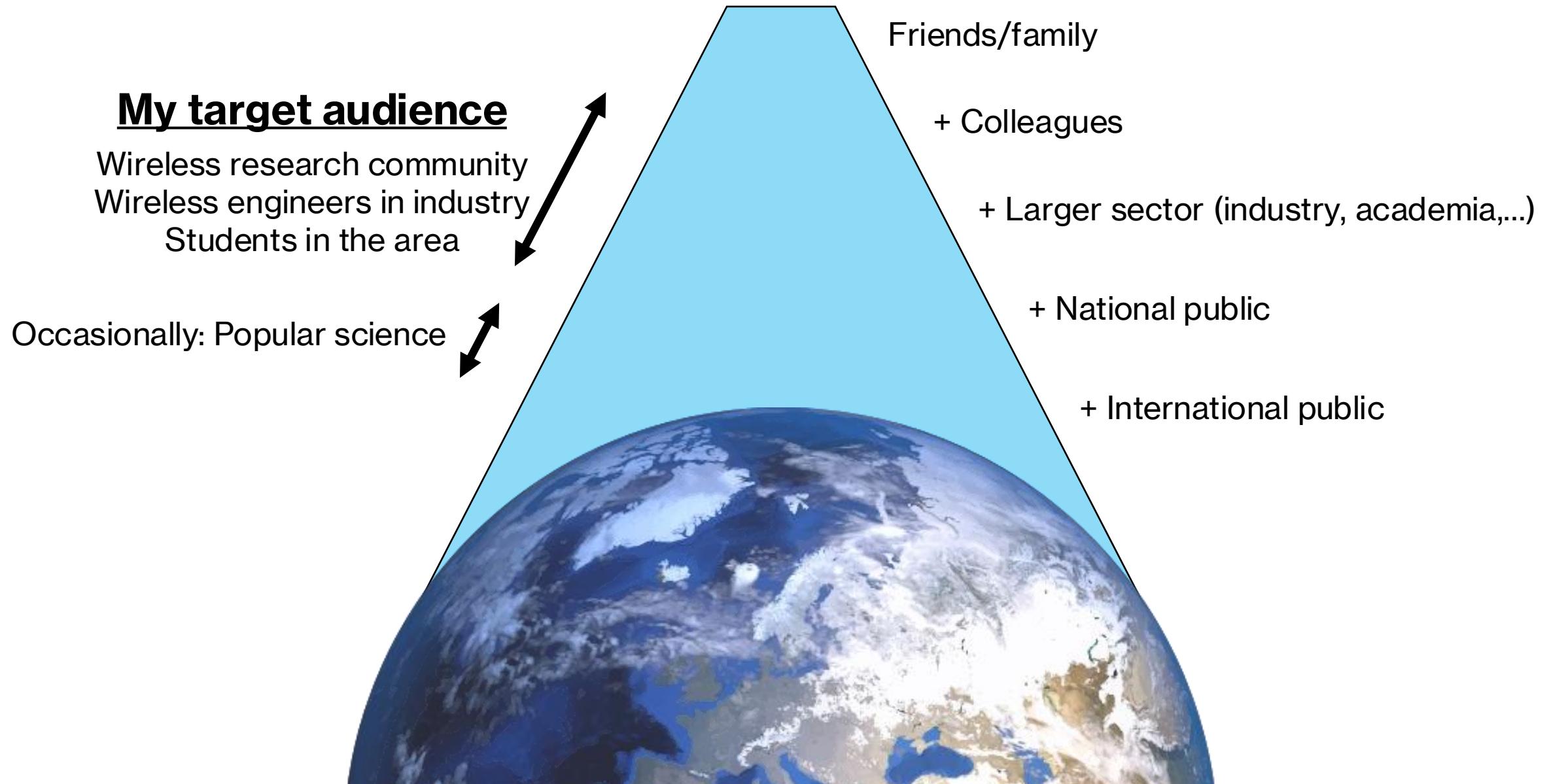


Emil Björnson

IEEE Fellow | Professor at KTH | Wireless Future on YouTube
Greater Stockholm Metropolitan Area · 500+ connections

**What role do I strive for in
the research community?**

Different target groups





Where it all started...



ResearchGate

GitHub

Product Team Enterprise Explore Marketplace Pricing

Emil Björnson
emilbjornson

Follow

Professor of Wireless Communication at KTH, Host of the YouTube channel Wireless Future, IEEE Fellow

1.4k followers · 5 following

KTH Royal Institute of Technology
Stockholm, Sweden

Popular repositories

massivemimobook Public

Book PDF and simulation code for the monograph "Massive MIMO Networks: Spectral, Energy, and Hardware Efficiency" by Emil Björnson, Jakob Hoydis and Luca Sanguinetti, published in Foundations and T...

MATLAB ⭐ 216 📈 119

IRS-relaying Public

Simulation code for "Intelligent Reflecting Surface vs. Decode-and-Forward: How Large Surfaces Are Needed to Beat Relaying?," by Emil Björnson, Özgecan Özdogan, Erik G. Larsson, IEEE Wireless Comm...

MATLAB ⭐ 70 📈 39

book-resource-allocation Public

Simulation code for the book "Optimal Resource Allocation in Coordinated Multi-Cell Systems" by Emil Björnson and Eduard Jorswieck, Foundations and Trends in Communications and Information Theory, ...

MATLAB ⭐ 55 📈 49

Five pillars



Blog

WIRELESS FUTURE

NEWS - COMMENTARY - MYTHBUSTING

WIRELESS FUTURE

NEWS – COMMENTARY – MYTHBUSTING

RECENT COMMENTS

Emil Björnson on Real-time Reconfigurable Metasurfaces

fazal sajid on Real-time Reconfigurable Metasurfaces

Zengbao Zhu on Rician Fading – a Channel Model Often Misunderstood

Emil Björnson on Rician Fading – a Channel Model Often Misunderstood

NEWSLETTER

Subscribe to get notification of new posts by email

[ABOUT THIS BLOG](#)[POPULAR POSTS](#)[WHAT IS MASSIVE MIMO?](#)

Four types of posts

1. Explanation of a concept
2. Comments on telecom news
3. Summary of a line of research
4. Links to other content

SS OR

[EAVE A COMMENT](#)

ations only specifies
a device from any

vendor (e.g., Apple, Samsung, Xiaomi) communicate with network infrastructure from any vendor (e.g., Ericsson, Nokia, Huawei). The exact implementation details (e.g., hardware

Traffic since September 2016



Time	Visitors	Views
Last week	5,303	20,270
Last 7 days	5,665	31,325
Last 30 days	21,108	92,151
Last year	161,338	680,430
Total	1,105,172	4,272,928

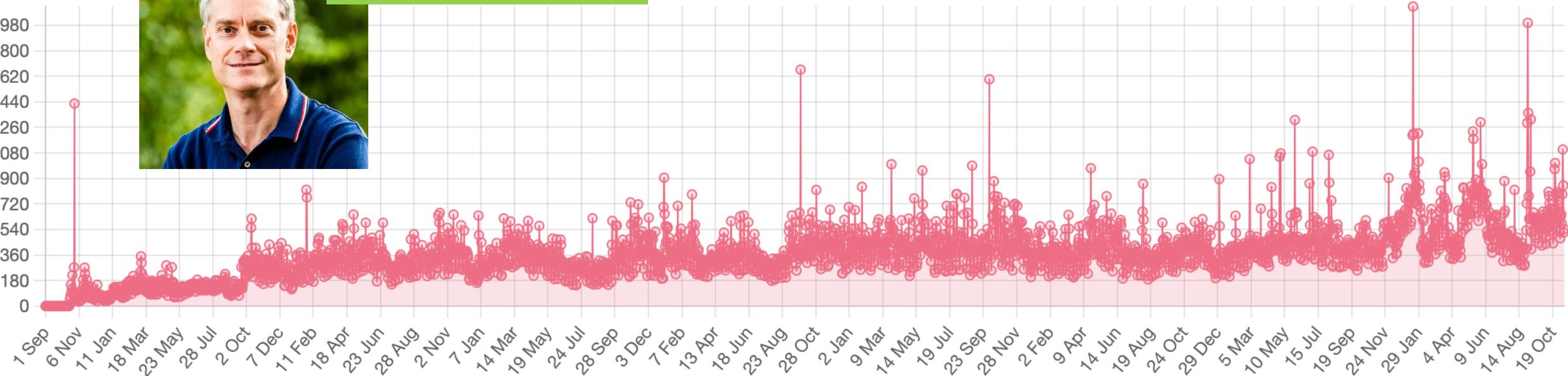
Country	Visitors
United States	244,204 »
China	141,202 »
India	100,586 »

Visitor map: October

Visitors



Prof. Erik G. Larsson



WIRELESS FUTURE

5G & BEYOND - RESEARCH - POPULAR SCIENCE



Wireless Future

@WirelessFuture · 27.2K subscribers · 165 videos

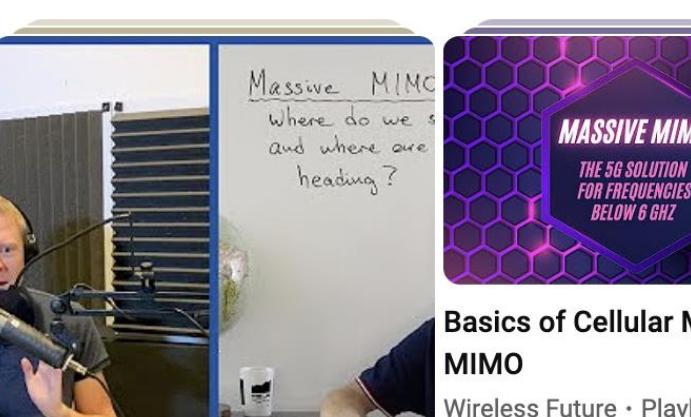
Wireless Future is a channel by Emil Björnson (Professor at KTH Royal Institute of Technology) ...[more](#)

ebjornson.com/research

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Overview of Playlists



Basics of Cellular MIMO

Wireless Future · Playlist

Six types of videos

1. Keynotes, invited talks
2. Conference presentations
3. Frequently asked questions
4. Lecture and overview videos for courses
5. Popular science
6. Podcast



videos

youtube.com/wirelessfuture

Wireless Future · Playlist

Wireless Future · Playlist

1

Higher spectral efficiency [bit/s/Hz]

- Spectral efficiency from information theory:
 - Expensive to increase: Each doubling require 17 times more power!
- Solution: Many simultaneous transmissions, *directed towards the users*

1 antenna MIMO-technology: 100 antennas

Record projector screen

▶ ▶ 🔍 13:45 / 18:55 • Higher spectral efficiency > CC HD

2

New Architecture: Radio Stripes

Record TV screen

3

2 Antenna units

APU 10 GHz 28 GHz 260 GHz THz

LiU LINKÖPING UNIVERSITY ERICSSON

▶ ▶ 🔍 14:20 / 23:16 • New Architecture: Radio Stripes > CC HD

Reinventing the Wireless Network Architecture Towards 6G: Cell-free Massive MIMO and Radio Stripes

3

Screen capture + Green screen

6G: What, why, and how?

▶ ▶ 🔍 0:00 / 18:44 CC HD

4

Input → Algorithm → Output

Data Measurements Software Decisions

Green screen + Animations

▶ ▶ 🔍 0:46 / 7:51 CC HD

What is the Role of AI in 6G Networks? [Frequently Asked Questions]

Course content

Techniques for overcoming physical problems of wireless transmission

- Modulation – use a signal format to send bits as efficiently as possible
- Error control coding – add extra bits so errors are detected/corrected.
- Adaptive modulation and coding – adjust to current channel conditions.
- Equalization – counteract the multipath fading effects of the channel.
- Direct sequence spread spectrum – expand the signal bandwidth
- Orthogonal frequency division multiplexing
 - Break a signal into many lower rate bit streams, each less susceptible to multipath problems

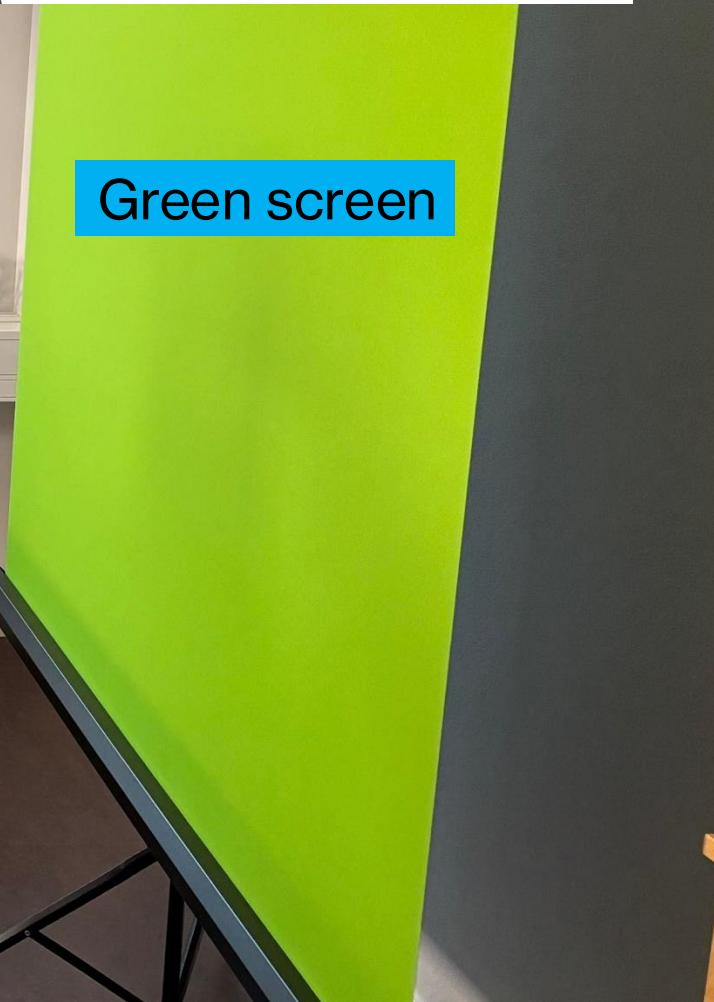
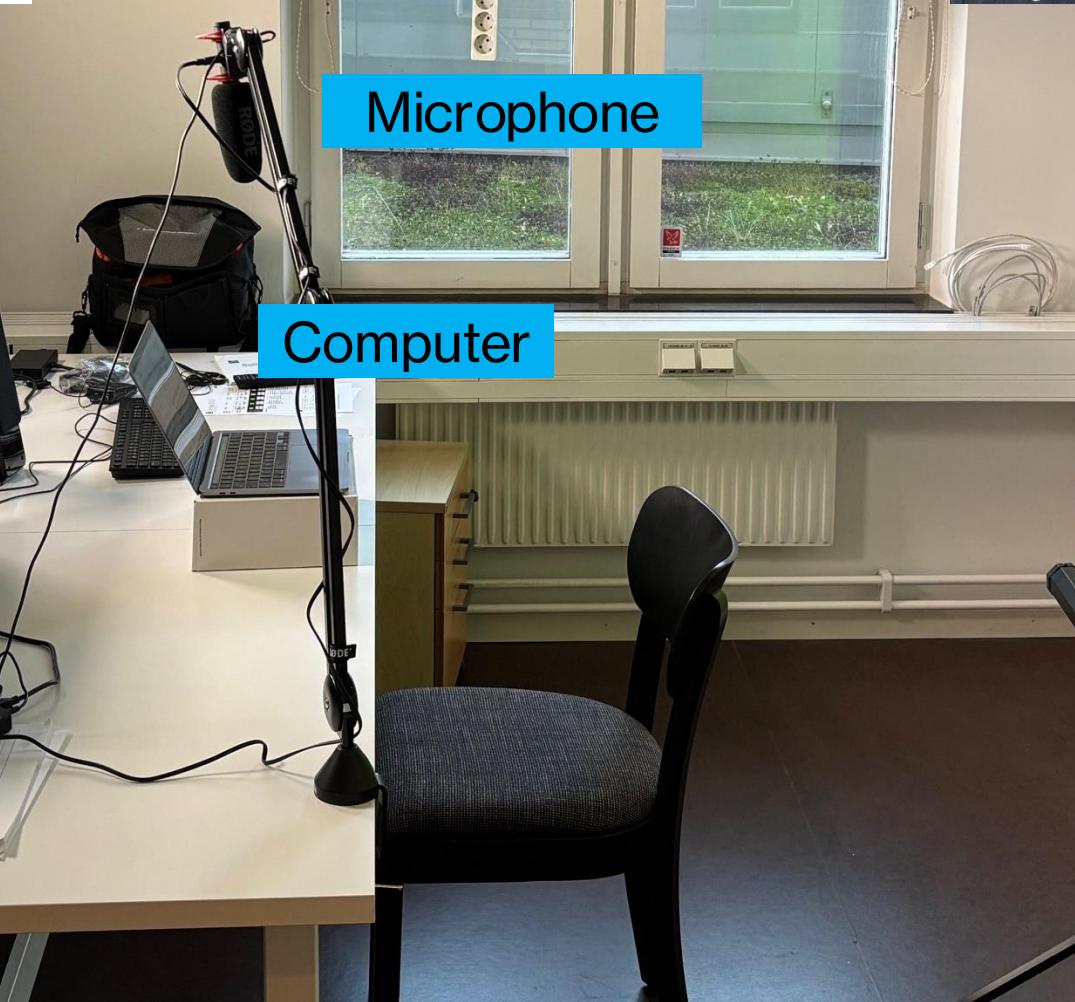


Course content

Techniques for overcoming physical problems of wireless transmission

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3



3

Dissecting the YouTube traffic (2016-2022)

18,500 subscribers
1,288,000 views
138,000 hours

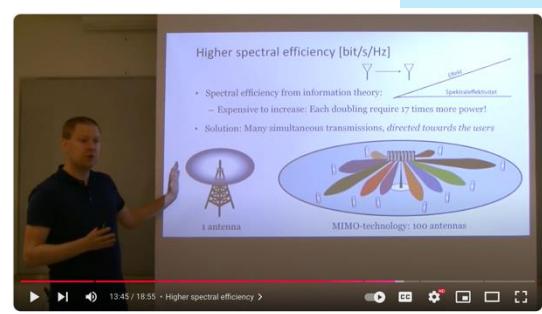


Today:

27,200 subscribers
2,152,000 views
197,000 hours

Pandemic started

Increased number of videos



Comments

All (1,458) | Mine (595) | Pending (0) | Approved (1,458) | Spam (638) | Bin (

Bulk actions

Apply

All comment types

Filter

Check for Spam

1,458 items

<input type="checkbox"/> Author	Comment
<input type="checkbox"/> Cell-Free Massive MIMO and Cloud-RAN Wireless Future Blog ma-mimo.ellintech.se/2022/04/30/cell-free-massive... 193.202.110.23	[...] are alleviated. We are essentially creating a wide-area network that is free from cells. There are different forms of Cell-Free Massive MIMO, characterized by where the baseband processing is carried out. It can [...]
<input type="checkbox"/> Emil Björnson emilbjo@kth.se 92.244.18.144	In reply to Prokins Wang. Yes, it can act as a magic mirror in that way. The phase shifts are moving the reflection angle from what you would expect from Snell's law. Equation (13) says how much it needs to be shifted. It depends both on the incident angle and the desired reflection angle.
<input type="checkbox"/> Prokins Wang prokinwang@gmail.com 127.122.219.9	In reply to Emil Björnson. Thanks for your kind reply! I have read this paper, and it says the phase shift of the RIS is designed according

Direct interaction with audience

Channel comments & mentions

Comments

Mentions

Published

Held for review

Filter

O

Oshea321 • 21 seconds ago

hi master student in wireless if possible can you do an analysis on pcell from artemis keep to hear your thoughts thanks



REPLY

0 replies



:

I will check it out

Noted

Great suggestion!

J

Jakob Hoydis • 25 minutes ago (edited)



Read more

Hi Erik, Emil, with respect to semantic communications, I think that the idea of animating avatars for reduced bandwidth or improved quality is

J

Jasmin Nadic • 1 hour ago

Just for the understanding, for RIS you need to provide it with power and additional, you need sensor to measure the propagation environment plus a communication link to steer the RIS, right? Thank you.



e Intelligent

Ep 29. Six 6G Technologies:
The cases for and against
[Wireless Future Podcast]

Ep 29. Six 6G Technologies:
The cases for and against
[Wireless Future Podcast]

Ep 29. Six 6G Technologies:
The cases for and against
[Wireless Future Podcast]

Podcast since October 2020

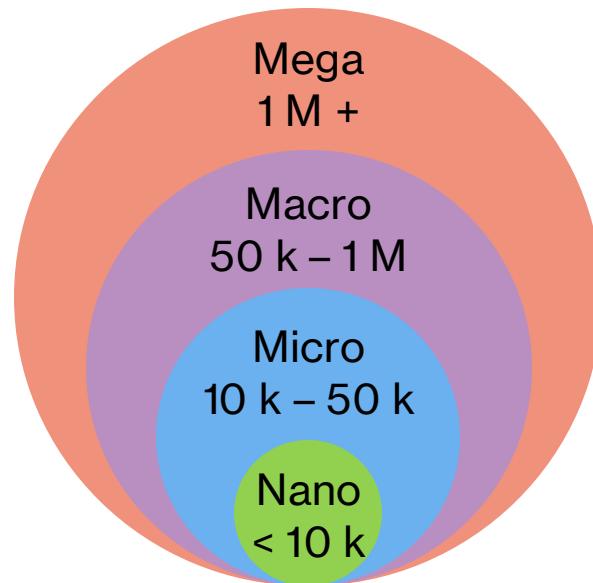


Influencers

Influencers have acquired or developed their fame and notability through the Internet



Four tiers:

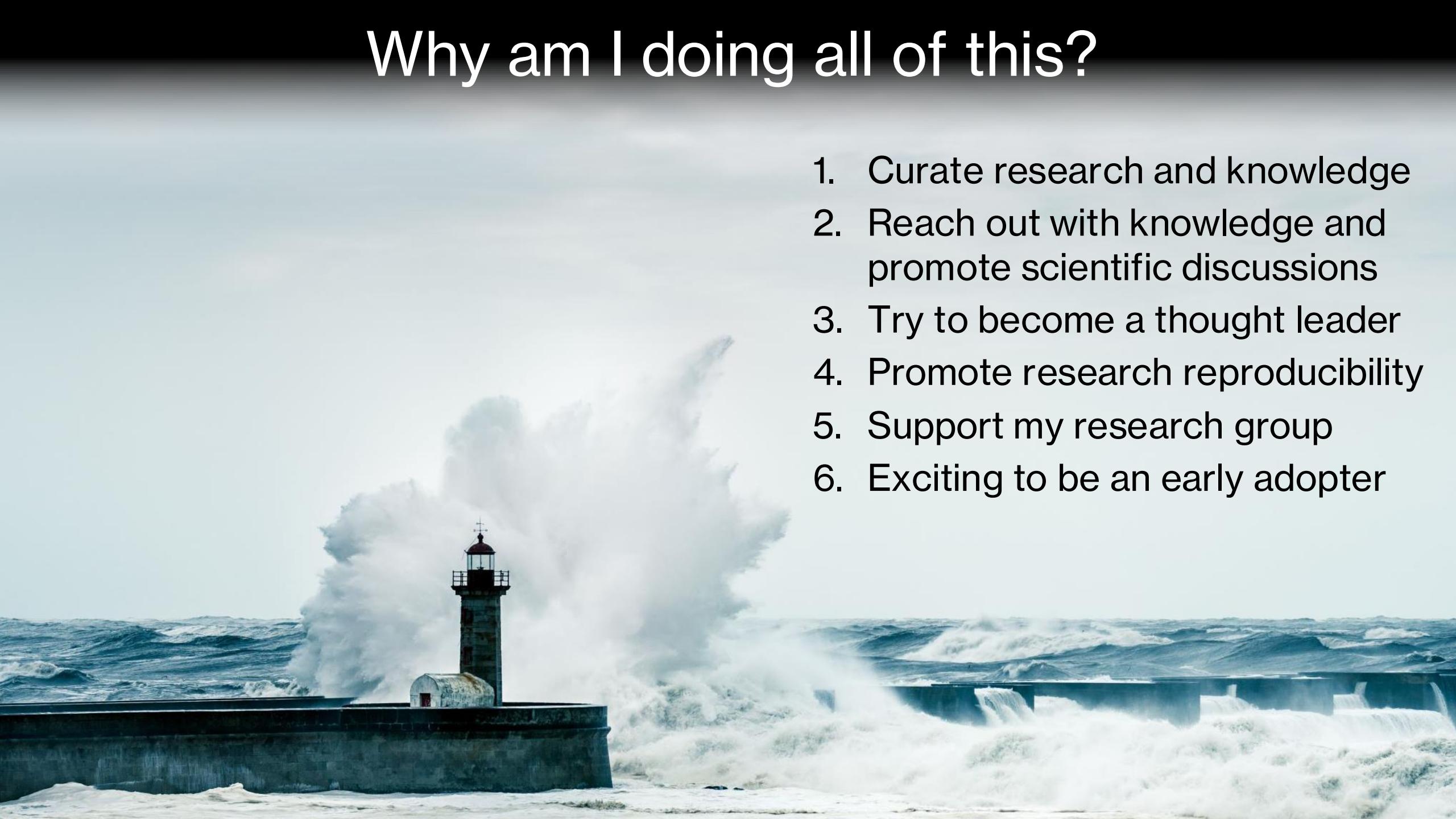


Purposes:

Influencer marketing
Self-branding

"a micro-influencer is a person famous within a niche group of users on a social media platform."

Why am I doing all of this?

- 
1. Curate research and knowledge
 2. Reach out with knowledge and promote scientific discussions
 3. Try to become a thought leader
 4. Promote research reproducibility
 5. Support my research group
 6. Exciting to be an early adopter

Do you want to become a *research influencer*?

1. Have a *goal* with your activities
2. It *takes time* to get an audience
3. Identify your *target audience*
4. Find the right *ambition level*
5. You benefit from *being generous*