Science AMA Series: I'm an MIT computer scientist who develops wireless solutions to network congestion/spectrum crunch. AMA!

Hariharan$_{R}ahul^{1}andr/ScienceAMAs^{1}$

[1]Affiliation not available

April 17, 2023

the WINNOWER

REDDIT

Science AMA Series: I'm an MIT computer scientist who develops wireless solutions to network congestion/spectrum crunch. AMA!

HARIHARAN_RAHUL R/SCIENCE

[removed]

CORRESPONDENCE:

DATE RECEIVED:
January 06, 2017

DOI:
10.15200/winn.148362.24251

ARCHIVED:
January 05, 2017

CITATION:
Hariharan_Rahul , r/Science , Science AMA Series: I'm an MIT computer scientist who develops wireless solutions to network congestion/spectrum crunch. AMA!, *The Winnower* 4:e148362.24251 , 2017 , DOI: 10.15200/winn.148362.24251

What are the challenges of bringing technology like this to the market?

firedrops

With wireless technologies, there are issues of standards and compatibility with end user devices - anything that requires standards changes or modifications to the hardware and software on laptops, tablets, phones etc. has a much higher deployment barrier. The nice thing about MegaMIMO is that it requires no such changes - it is implemented completely on the access points/base stations/small cells.

Military trained Spectrum manager here! How did you increase speed? By increasing bandwidth by adding transmitters? How big can you get the bandwidth ? Is there a limit on the reciver end or transmitter ? How do you prevent interference with multiple transmitters? Do you get interference over distance due to ground resenance waves and or right angle reflection?

Mr_Locke

We increase speed in dense networks by allowing many transmitters to transmit at the same time in the same frequency without interfering with each other. The main goal is to get the most performance from limited spectrum. Our algorithms coordinate the transmitters and modify the signals they transmit so that they don't interfere at the different receivers. We don't have problems from reflection or resonance - our system changes the waves the transmitters form to account for this.

What did you know before you took any college courses. Did you teach yourself anything before being taught?

Videokid524

I always liked math and physics, and liked playing with the old ZX spectrum we had at home growing up. But, while I enjoyed logical puzzles and problem solving, my serious experience with computer programming only came in undergrad.

Is it an expensive technology to implement?

bastingmylife

Not at all. As I mentioned elsewhere, it doesn't require any changes to people's physical devices - it's implemented completely on the access points, and even then, it requires very minimal changes to the APs. Between those two factors, the expense is negligible.

Also, it provides significant cost benefits. As you know, today's cellular wireless spectrum is really expensive, but MegaMIMO can make the spectrum 10 times more efficient.

I have a question specifically about MIT. My girlfriend goes there and I know that plenty of groundbreaking things are done by MIT alums. What was your experience of the school like? Was it hell for you too?

rootbeergoat

MIT is certainly like drinking from a firehose, and it may not be for everyone. But I enjoy it. It's exciting and energizing to be among smart people full of intellectual curiosity.

One of the biggest problems in major metros, especially the one I live in, is that the spectrum is so divided across the wireless companies that getting full bandwidth is practically impossible.

What type of solutions would you like to see recommended at the state level to ensure better end-user performance due to spectrum realignment?

cheeseyone

I think some level of spectrum fragmentation is just unavoidable since different entities want to be able to have exclusive use of spectrum for planning and predictability. But I think there is a lot can be done algorithmically to squeeze performance out of the spectrum. The current standards are generally good about getting high individual link speeds (i.e. when there is a single transmitter and receiver), although there are some gains to be eked out here. The big opportunities are to improve spectrum utilization in larger networks - efficiently dealing with interference, sharing in a fine grained manner based on performance and traffic, using MIMO well, and so on. There are efforts on all these fronts by researchers and standards bodies as well. Of course, more spectrum is always nice, and more dynamism in sharing spectrum between organizations is nice as well, and the FCC, DARPA etc. are pushing on these.

Are there any cool algorithms, parallel or otherwise, behind the tech?

drsjsmith

Yes! We developed special distributed signal-processing algorithms that are lightweight and can coordinate multiple transmitters by synchronizing their phases. This allows the access points to transmit data on the same piece of spectrum to multiple different receivers without having any interference.

So I get that putting the signals in phase prevents destructive interference, but how can the various

receivers differentiate which portion of the signal is attributed to the transmitter that it is trying to contact?

PrettyMuchBlind

The way MegaMIMO works - each receiver only gets the data that is intended for it. The transmitters work together and modify the signals they transmit so that at each receiver, the signals intended for other receivers cancel out. That way, the receiver doesn't need any modifications - it behaves just like it does today, simply decoding the signal that it receives, and extracting its data.

I doubt this has anything to do with 802.11ax? If not do you think your work ill make it into the next iteration of 802.11 standards?

PrettyMuchBlind

We aren't working with the standards bodies currently - MegaMIMO doesn't need any standards changes to deliver its gains and works with off-the-shelf 802.11 g/n/ac devices, but it is something we are considering for the future.

The work was funded by the National Science Foundation and supported by members of the MIT Center for Wireless Networks and Mobile Computing.

Does this mean the technology is "open" and could be used by commercial enterprises for free?

redditticktock

We have published several papers where we outline the general parameters of the technology. These works have been cited and built on by others in the wireless academic community, and we definitely encourage researchers to expand on our work! We also have a few patents related to the system, since we are currently in the process of commercializing the technology.

Hi Hariharan, please ELI5 how "MegaMIMO" is different and/or similar to MU-MIMO, a standards based approach to transmitting simultaneously to multiple clients on the same channel (access point).

My understanding of MU-MIMO is that it too allows for real-time PHY transmission across an AP's multiple radio chains (all on same channel) but without the phase-based algorithms you are citing.

Also, have you used Ubiquiti Networks Access Points?

Thanks for doing this AMA!

pwnfps

Great question! What MU-MIMO does is have a single transmitter transmit data simultaneously to multiple receivers. But one transmitter can only transmit to at most as many receivers as it has antennas (due to the MIMO constraint of degrees of freedom). What MegaMIMO can do is get **multiple** transmitters to transmit data simultaneously to multiple receivers, using our synchronization and coordination algorithms. This means that we can transmit to *many* more receivers than a traditional MU-MIMO system. What we've shown in our implementation is that we can transmit to 10x more users than existing wireless systems.

Thanks for doing this AMA.

Wireless Guy here, What are your thoughts on LTE-U and,generally, the weakness inherent in the OFDM channel vs an OFDMA channel?

LTE was defined by 3GPP to address some of the capacity concerns inherent in WiFi. Do you think non-commercial services could be better served by altering the channel technology delivered?

edit: Addressing mega MIMO....What amount of decorrelation is needed to get the full throughput gain? Is it just an addition of channles in the H matrix or is there something else going on?

At_least_im_Bacon

I think OFDMA makes a lot of sense when there is a lot of frequency diversity, either due to significant multipath, for example, in outdoors deployments, or as the channel bandwidth increases (for instance, the maximum channel bandwidth in modern 802.11 standards is 160 MHz). The typical 802.11 use case is indoors and with smaller channel bandwidths though - in which case, regular OFDM does well enough. There are other questions about channel access - LTE-U has a more centralized, scheduled model vs. Wi-Fi's distributed random access. The centralized model can definitely be more efficient, but how it will work when the spectrum is shared with other users is still an open question. I think questions on spectrum etiquette will need to be resolved before LTE-U becomes more widely adopted.

Good question about the decorrelation. MIMO typically is limited in the benefits it can provide as you add more antennas to a transmitter as the additional channels tend to be correlated, and the gains flatten out. MegaMIMO doesn't have this issue. Since the antennas are on distributed transmitters, they have much higher spatial separation than in regular MIMO, and can harness many more degrees of freedom. So, the matrices tend to be full rank even for large number of antennas.

I was wondering one day why cell phone networks don't use mesh networking. it seems intuitive that you can increce coverage and reduce power usage by allowing cell phones to connect to the tower through each other. all security issues should be solvable by device-to tower encryption. am I missing something, or am I on to something here?

DJWalnut

Mesh networking could increase range, but introduces other issues, particularly with spectrum planning or scheduling. The different links in the mesh have to share spectrum, so that reduces the throughput any single user can get. And there is an issue of scheduling the different links so they don't interfere with each other. In practice, for dense situations like urban areas, it is usually simpler to make the wireless network a last hop network and use wired infrastructure for the rest. Mesh networks are indeed used for coverage in more rural areas, for example, in the midwest, as well as in certain cases in South East Asia and so on. But even in these cases, it is only the infrastructure that is meshed, not a peer-to-peer mesh of cell phones.

[removed]

[deleted]

Richard Hendricks worked for us before he started Pied Piper.

How is this different from the GPS Sync that professional long-range wireless systems use - WiMAX, Canopy, ePMP (which is based on wifi chipset) - etc other than being applicable to standard Wi-fi

protocol?

CStanners

The GPS Sync that is used in these outdoor wireless systems is usually only for tight time multiplexing i.e. to get different transmitters to transmit in different time slots. It doesn't allow these transmitters to transmit in the same time slot in the same frequency without interfering with each other - this is what MegaMIMO does.

As a second matter, GPS Sync doesn't work in indoors networks or for devices where the power and cost of GPS clocks is not an option. MegaMIMO doesn't require GPS Sync or GPS clocks to deliver its coordination across multiple transmitters.

Were there any general learnings from your time at Akamai that you were able to use for this problem in the wireless systems area? What motivated you to pursue this research topic?

Arnie001

My work at Akamai was on the wired Internet, so it is technically quite different. But I gained a lot of experience building robust and scalable systems at Internet scale while working at Akamai, and that is experience that was helpful to me while in grad school.

I find it a lot of fun to work on wireless systems for a couple of reasons. First, the theory underlying wireless communication systems and signal processing is really quite deep and fascinating, and I enjoy studying and thinking about it. And it is interesting to then take this theory and come at it from the philosophy and aesthetic of Internet design, which tends to focus on distributed rather than central planning. That's broadly been the thrust of my research, for instance.

While working on MegaMIMO, did you ever hit any memorable roadblocks which forced you to change the direction you were working on? If so, could you talk about the most memorable challenge?

samyuktha_s

The work that eventually became MegaMIMO evolved over several years and includes several different ideas. Of course, with research, there are always challenges, but that's the fun - each challenge hopefully comes with its satisfying aha moment! I still remember a week of sleepless nights when I finally got a first version of the system working, showing that we could actually coordinate transmitters very well, but that version still involved changes to end user devices. I wasn't even explicitly thinking about removing that constraint, but I guess it was sitting somewhere in the back of my head. That night, as I was walking home from the lab - completely exhausted and ready to go to bed, it suddenly occurred to me how I could do it without changing end user devices. And poof, there went a few more hours of sleep as I stayed wide awake trying to work out the details :)

Does this coordination allow any guarantees that adding an extra access point to an existing set will always strictly improve or leave unchanged every client's access?

OptimallyOptimistic

Yes, it does.

Better speed via multiple transmitters on the same frequency (utilizing what I can only imagine is a

more advanced TDMA) is great, but I don't imagine that it helps a whole ton when you're talking a *very* densely packed location with a bunch of low to mid end client devices all generating their own noise. Do you imagine that this technology could or would help dense environments such as front of house at a music festival, possibly 20-40K people? Additionally, how many antennas is this designed for, and would this technology be utilized in a similar fashion to say Extricom Wireless?

dmanners

This kind of dense topology - stadiums, convention centers, conferences etc. is exactly what MegaMIMO is targeted at. MegaMIMO works with clients with any number of antennas - either one antenna or multiple antennas (cellphones often have 2, laptops might even have 3). It can coordinate multiple transmitters, with each transmitter again having a variable number of antennas, and deliver its performance gains by having all these antennas cooperate to transmit jointly. Overall, it can harness many more antennas than the single transmitter solutions out in the market today.

MegaMIMO is more sophisticated than TDMA, though, and that's where it gets its gains - it can actually have multiple transmitters transmit simultaneously, instead of scheduling them in different time slots as TDMA would do.

Anything you can do to help me alleviate congestion on my network? Ever since I added 3 more HD Wi-fi IP cams my router hates me and my network has become noticeable slower.

Throwawayhobbes

Buy MegaMIMO when it is out! :)