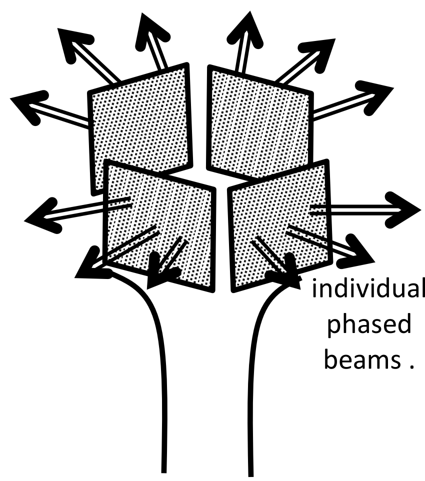
The following examples indicate how ULTRALOGIC 6G Standard-type Solutions can benefit 6G.

INSTANT BEAM ALIGNMENT

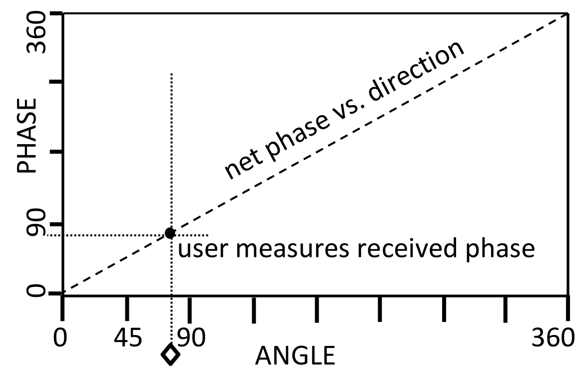
Problem: Beam alignment is slow and costly, serving just one user at a time.

Solution: The base station can broadcast a single "alignment" pulse, emitting a different phase in each direction. Each user measures the phase at its location, and immediately knows its beam alignment angle based on the observed phase. Every user in the network can be aligned instantly, without a beam scan.

ALIGNMENT PULSE



Beamlets emitted around, blend to form the alignment pulse.



User measures phase at own location. Alignment angle to base station equals the received phase, in degrees.

Options: (a) Transmit the alignment pulse on the broadcast channel, before or after the SSB message, so new users can align their reception beams before receiving the system information messages. (b) Base station can also transmit a "calibration" pulse with the same phase in all directions. It is transmitted in the same symbol-time, canceling phase noise. (c) For higher resolution, the base station can transmit a "vernier" pulse with phase varying faster, such as 360 degrees in phase for each 90-degrees in angle. (d) Digitally-controlled phased-array antennas can form such pulses directly. The pulses can also be produced by multiple analog/hybrid antennas with overlapping phased beams, among other ways. (e) Users can tell the base station later, if the angle has changed, such as appended to a BSR or acknowledgement message.

Value-Chain:

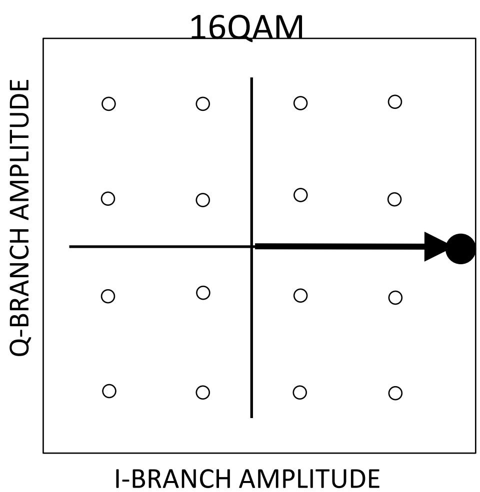
► **For the user,** acquiring beam alignment early in the initial access process enables faster, error-free reception of the system information messages, reliable transmission of the RACH preamble and other entry messages - without a power scan or beam scan - for rapid network access at zero cost. In addition, mobile users can update their alignment every 20 milliseconds.

► **For the network,** the network can avoid the current process of transmitting the SSB multiple times in different directions, a waste of energy. The network can also receive the new user's access messages with high signal clarity when beamed. This also greatly simplifies handoff between cells by ensuring beam re-alignment rapidly and deterministically.

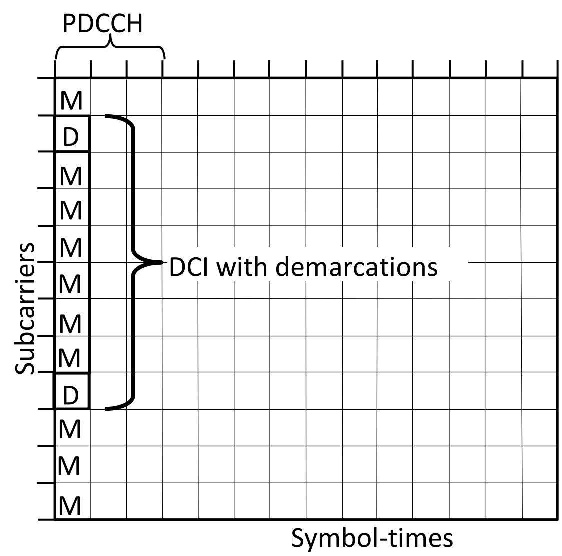
EASY DCI MESSAGE RECEPTION

<u>Problem</u>: Users have trouble recognizing their downlink control (DCI) messages. This compute requirement is the largest battery drain for many IoT devices. Cheap microcontrollers cannot do it, thus driving up IoT costs. Some messages are ultimately missed.

<u>Solution</u>: The base station can demark each DCI message, start and end, with a unique modulation symbol. In QAM, for example, each state has a positive or negative amplitude in the I and Q branches. The special demarcation could have large positive I branch, and <u>zero</u> amplitude in the Q branch. It is easy for the receiver to detect this unique modulation by scanning for zero Q, instantly localizing each DCI message for decoding.



<u>Special demarcation symbol</u>. Full amplitude in the I branch, and ZERO amplitude in Q branch. This is easily detected by receivers.



DCI messages can be demarked by the special demarcation symbol (D) at the start and end.

<u>Options</u>: (a) Use the opposite modulation (high Q, zero I) to indicate something else. (b) For better noise cancellation, add a short demodulation reference in the message. It can be separated by another special demarcation. (c) Users can request using demarcations for their messages if they want them. (d) Demarcations can also be used on the PDSCH messages. This may eliminate the need for downlink scheduling DCI entirely, thereby reducing latency and power.

Value-Chain:

► **For the user**, demarcations enable easy isolation of individual DCI messages, greatly reducing compute costs, extending battery life, and enabling RedCap devices with minimal processors. The cost is zero, other than a minor software update.

► **For the network,** the demarcations cost nothing because the 24-bit CRC can now be reduced to the regular 16-bit version, compensating for the extra resource elements of the demarcations. In addition, custom search spaces can be reduced or eliminated, resulting in greater scheduling flexibility, reduced latency, and more efficient use of the bandwidth.

TEMPORARY QoS ELEVATION

Problem: Low-priority devices cannot send an alarm message, even in an emergency.

Solution: To transmit an emergency alarm, the IoT device can attach a special code to its scheduling request or BSR (or on the random access channel). This causes the base station to handle the associated message with top priority. There is no change to the device's default QoS.

EXAMPLE: A temperature sensor, with very low QoS, is used to controls an air conditioner. Suddenly, the sensor sees dangerously high temperatures - the house is on fire! The sensor has to get the message out fast, before being destroyed by heat! But its low default QoS prevents it from accessing emergency services, and the house burns to the ground. If the sensor had been able to request a single emergency message, the house would have been saved.

As another example, a cyber attacker may invade a vulnerable IoT device. The device detects it, but cannot transmit an alert fast enough before being disabled by the attacker. A temporary single-message priority option would have enabled the alert.

Options: There may also be times when a high-priority user wishes to send a non-emergency message. They can then request a low QoS, using a second code, for a single routine message. For example, a first-responder station normally has a very high default QoS. But suppose it wishes to send a routine, non-emergency message. To do so, it uses the second code to request a temporary QoS reduction, and thereby avoids wasting resources when there is no emergency.

Value-Chain:

► **For the user**, the ability to transmit an emergency message could be life-saving. Even a basic IoT device could detect a time-sensitive situation such as a danger to equipment or people, a cyber attack in progress, or other event requiring fast response. The device could get the priority needed, while avoiding the arduous process of changing the default QoS, and other delays.

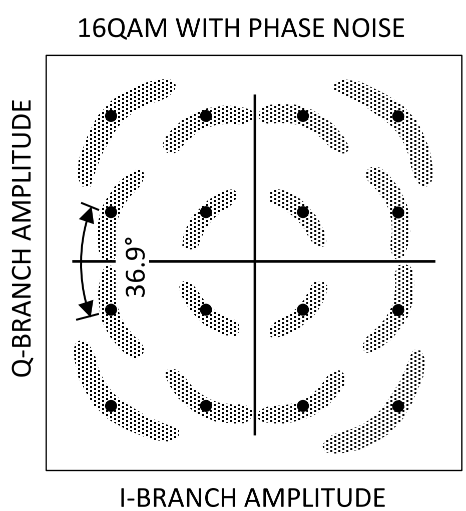
► **For the network,** the added capability of users to demand emergency priority is practically zero-cost, since it only requires a simple software addition to recognize the priority-request codes. The network also would avoid the resource costs and energy involved in altering the user's default QoS. In the unlikely situation that someone abuses the emergency request, the base station can simply withdraw the privilege. This capability can also fulfill the emergency responsiveness requirements that all networks are expected to provide.

PHASE NOISE MITIGATION

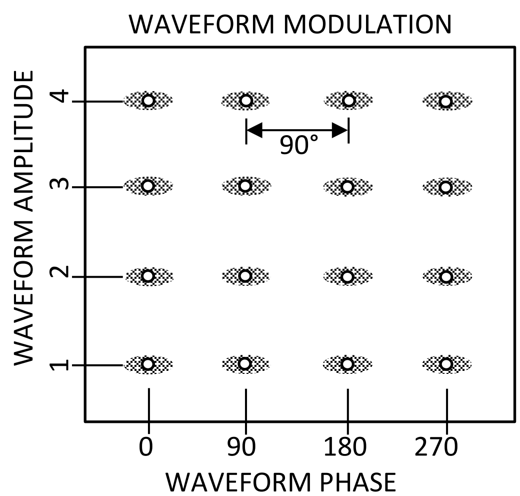
Problem: Phase noise is a limiting factor at high frequencies. The source of the problem is that QAM has low phase margins.

Solution: Modify the constellation chart for larger phase margins.

EXAMPLE: Phase faults at high frequencies are primarily due to the close spacing of certain QAM modulation states. In 16QAM, for example, the nearest neighbors are only 36.9 degrees apart, resulting in extreme phase vulnerability. An easy solution is to modulate the signal by direct amplitude and phase modulation of the overall waveform. For example, modulating the waveform with four amplitude levels and four phase levels provides 16 states, in which every state has a guaranteed 90-degree phase margin. This provides the same throughput as 16QAM, uses the same transmit power, employs the same receiver, and costs nothing.



Phase noise is shown in gray. The closest neighbors have inadequate phase margins, as indicated by the near-overlap.



The 16 states of waveform amplitude-phase modulation, with the SAME AMOUNT of phase noise as the QAM chart. It only looks smaller because the phase margins are much larger.

Options: (a) Multiplexed amplitude and phase modulation of the overall waveform is an easy option. Operationally, the receiver measures the I and Q amplitudes as usual, and then the demodulator calculates the waveform amplitude and phase using standard formulas. (b) The network can discriminate phase faults, additive amplitude faults, and interference, and (c) mitigate each fault type using asymmetric modulation tables, which are impossible in QAM.

Value-Chain:

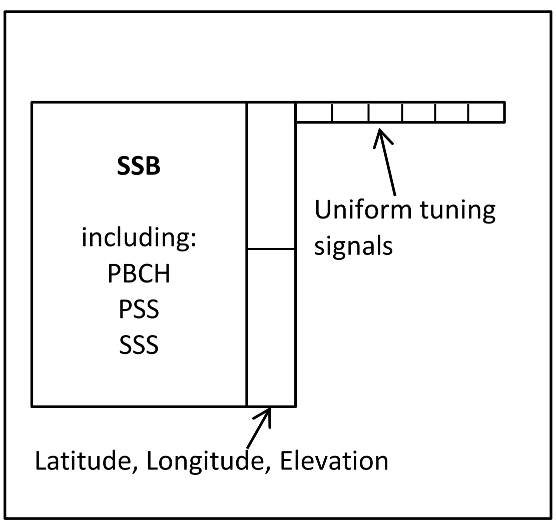
► **For the user,** the waveform-based phase margins enable greatly increased throughput by accessing higher frequencies, while avoiding the interruptions and costs of phase faulting.

► **For the network,** the increased flexibility to access higher frequencies enables higher network performance at no cost. Diagnosing faults according to type enables a fault-specific mitigation such as asymmetric modulation tables, which QAM cannot provide.

INITIAL POWER ADJUSTMENT

Problem: New users do not know how much power to use in transmitting their RACH preamble. Hence they are required to do a tedious and time-consuming power scan.

Solution: The base station indicates the location of its antenna in the SSB message, or in a fifth symbol attached to the SSB. New users can then easily calculate the distance, and estimate the proper power level, before transmitting the RACH preamble. Users can also align their beams toward the base station for enhanced signal quality.



The first system-information message (SSB), followed by the coordinates of the base station's antenna. A series of uniform tuning signals also help user devices align their reception beams.

Options: (a) The SSB can be followed by a series of uniformly transmitted signals, which the user device can use for fine-tuning its reception beam direction and width. (b) Mobile users can adjust their beam directions as they move around, thereby providing a re-alignment every 20 milliseconds, at no cost. (c) Mobile users can also calculate the Doppler correction based on the antenna location relative to the user's velocity.

Value-Chain:

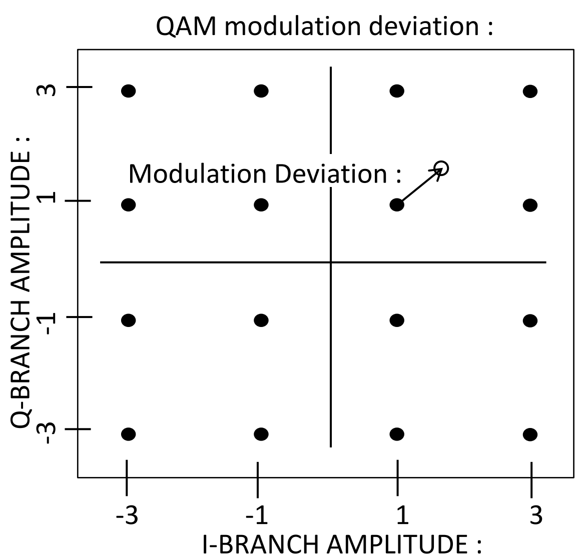
► **For the user,** adjusting the reception and transmission beams in the initial-access process provides greatly increased signal quality with reduced power usage. It also eliminates the RACH power scan since the distance is known. For mobile users, the ability to maintain alignment enables automatic Doppler correction based on the mobile user's direction.

► **For the network,** the modified SSB can be transmitted once, isotropically, instead of multiple times in multiple directions, thus saving time, power, and resources on the broadcast channel. This more than compensates for the extra symbols transmitted.

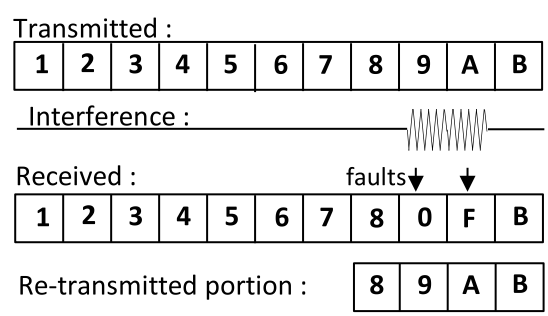
EFFICIENT MESSAGE RETRANSMISSION

Problem: Message faulting is an increasing problem. Currently, the entire message is automatically retransmitted, consuming resources and time. This is a waste because, in most cases, the faults are clustered in a portion of the message.

Solution: The receiver can determine where the faults are located, based on the modulation deviation. It can then request retransmission of the faulted portion only. This saves time and resources, especially with long messages.



Receiver can identify the faults based on the modulation deviation. The modulation deviation is the distance between the as-received modulation (open circle) and the nearest of the predetermined modulation states.



In this example, two message elements were distorted by noise or interference. The receiver identified the bad message elements and requested a short retransmission of only that faulted portion. It thereby corrects the message with minimal resource and power usage and background generation.

Options: (a) The receiver can use other fault signatures of the waveform to identify the faulted message elements, such as the width of amplitude fluctuations in each message element, width of phase fluctuations, polarization different from the other message elements, frequency offset relative to the subcarrier nominal. (b) The user can indicate which portion to retransmit by appending a short code to a NACK.

Value-Chain:

► **For the receiver,** isolating the message faults results in a shorter retransmission. Message correction is then trivial. Substituting the retransmitted portion is a deterministic repair, as opposed to the problematic FEC bits. The cost is simply the software to detect fault signatures.

► **For the transmitter,** retransmitting just a portion of a message involves fewer resources and lower energy usage than retransmitting the entire message.

CASCADED POLLING

Problem: After a DRX sleep interval, the IoT device wakes up and needs to know whether it has any messages on hold.

Solution: The base station can indicate which users have messages on hold, using a cascaded polling code. "Cascaded" means dividing the users into sections, and indicating which sections include at least one waiting message. Then, it indicates which users - within those sections - have messages waiting. Cascading is highly resource-efficient when most sections have no messages on hold, as is commonly the case.

EXAMPLE: The base station first divides the user devices into sections, and assigns each user device to a particular address within its section. The base station transmits a "polling message", indicating which sections have at least one message on hold, followed by an "address" message identifying the waiting users in each of the indicated sections. Normally, only a few users will have messages waiting, in which case the base station does not transmit the address messages for the non-waiting sections; it only transmits address messages for the sections that have at least one message on hold. Users in the non-waiting sections can go back to sleep immediately after the initial polling message, since they know they have no messages on hold. Also, users in the waiting sections can go back to sleep if their addresses are not cited. The base station can then provide a "reply area" in which each cited user can indicate that it is ready to receive its messages, by placing a signal in its assigned space of the reply area. If the user is not ready, it transmits nothing. The base station then determines which users are ready to receive their messages according to which positions in the reply area have a signal, and transmits their messages in order.

OPTIONS: Scheduling requests can also be cascaded using the same bit-level code. If a user wants a grant, it can first transmit a signal in a predetermined uplink resource element according to its section number, and then can identify itself by transmitting a second signal in a subsequent resource element according to the user's position within that section. The base station can then identify that user according to the section number and the position within its section, and can provide a grant to that user.

Value-Chain:

► **For the user,** the cascaded polling and scheduling requests enable more frequent communication between the user and the base station, at little or no extra cost due to the efficient format of the messages. In addition, users that are in sections without messages on hold can go back to sleep immediately, instead of wasting further time on the subsequent transmissions.

► **For the network,** with cascaded polling and scheduling, fewer resources and lower energy transmission are required. Since the reply area signaling is modulation-agnostic, any signal in the reply area triggers a grant to the associated user, thereby saving time and resources..

SUMMARY OF ULTRALOGIC 6G ADVANTAGES FOR STANDARDS-TYPE SOLUTIONS

Instant Beam Alignment:

- ► **For best signal quality**, enable beam alignment as early as possible.
- ► **Mobile users** get frequent re-alignment at no cost.
- ► **Saves power** since the SSB can be transmitted only once, isotropically.
- ► **Simplifies handoff** by enabling instant beam realignment.

Easy DCI Message Reception:

- ► **Easy identification of each DCI**, greatly reducing compute burden, at no cost.
- ► **Enable basic RedCap** devices that cannot handle current PDCCH.
- ► **Reduce CRC to 16 bits**, thereby compensating for the demarcation resources.
- ► **Simplify scheduling** by reducing or eliminating custom search spaces.

Temporary QoS Elevation:

- ► **Enable emergency message**, instantly, anytime, at zero cost.
- ► **Raise alarms** due to hazard or cyber attack, reliably and with zero delay.
- ► **Fulfill network** responsibility obligations for emergency services.

Phase Noise Mitigation:

- ► **Higher throughput** by accessing high frequencies, without phase faulting.
- ► **Fewer interruptions,** better reliability, reduced latency at zero cost.
- ► **Improved network flexibility** by adjusting MCS to mitigate specific fault types.

Initial Power Adjustment:

- ► **Early beam alignment** and uplink power setting, at zero cost.
- ► **Superior signal quality** for system information acquisition and initial access.
- ► **Maintain alignment and Doppler** correction for mobile users.
- ► Single i**sotropic SSB,** thereby reducing power, resources, background generation.

Efficient Message Retransmission:

- ► **Rapidly isolate faults** based on modulation and other signatures.
- ► **Reduce size** of retransmission, when necessary, thereby saving time and power.

<u>Cascaded Polling:</u>

- ► **Users get messages**, easily, promptly, at reduced cost and power.
- ► **Greatly reduced** resource and energy consumption.
- ► **Early reveal** if no messages on hold, users can go back to sleep immediately.

OTHER SOLUTIONS TO 6G PROBLEMS

UltraLogic 6G also provides many other 6G solutions in the areas of:

► **<u>Precision synchronization including RedCap-compatible synchronization.</u>** Extending the timing procedure to reduced-capability IoT devices greatly broadens the opportunities for cost-constrained use-cases while maintaining network coherence.

► **<u>Agile network optimization using novel modulation schemes.</u>** With waveform amplitude-phase modulation, the network gains the flexibility to use asymmetric modulation schemes, not possible in QAM. For example, to counter amplitude faults, switch to an asymmetric modulation scheme with fewer, spaced apart amplitude levels and more phase levels.

► **<u>Phase tracking signals embedded in the guard-space between symbols.</u>** A precision phase-tracking signal is a 180-degree phase reversal in the middle of the guard-space. The receiver can measure the position (timing) of that phase reversal and obtain improved phase control.

► **<u>Cyber-secure IoT network topology with protected links.</u>** Protected links are sideband or non-3GPP links between basic IoT devices and their manager/gateway hub devices. They can be configured to effectively prevent cyber intrusions while supporting the communication needs of the IoT device.

WINNING THE FUTURE: SUPERIOR 6G PERFORMANCE

All novel UltraLogic 6G patented solutions are dedicated to improving network performance and enhancing user experience. Wireless leadership companies value extremely efficient networking and very delighted customers. – and are therefore encouraged to call us. Thank you.

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