September 2015

Creating a Digital 6th Sense with LTE Direct

QUALCOMM®
Why Wait™

LTE Direct is creating a Digital 6th Sense through always-on proximal discovery services

1

Always-on device-to-device discovery of friends, services, offers in one's proximity

Proximal discovery services efficiently integrated with existing LTE Advanced services and networks

2

Required to scale up from today's location-based and proximity beacon solutions

Privacy sensitive and battery efficient discovery of 1000s of devices/services in the proximity of ~500 meters

3

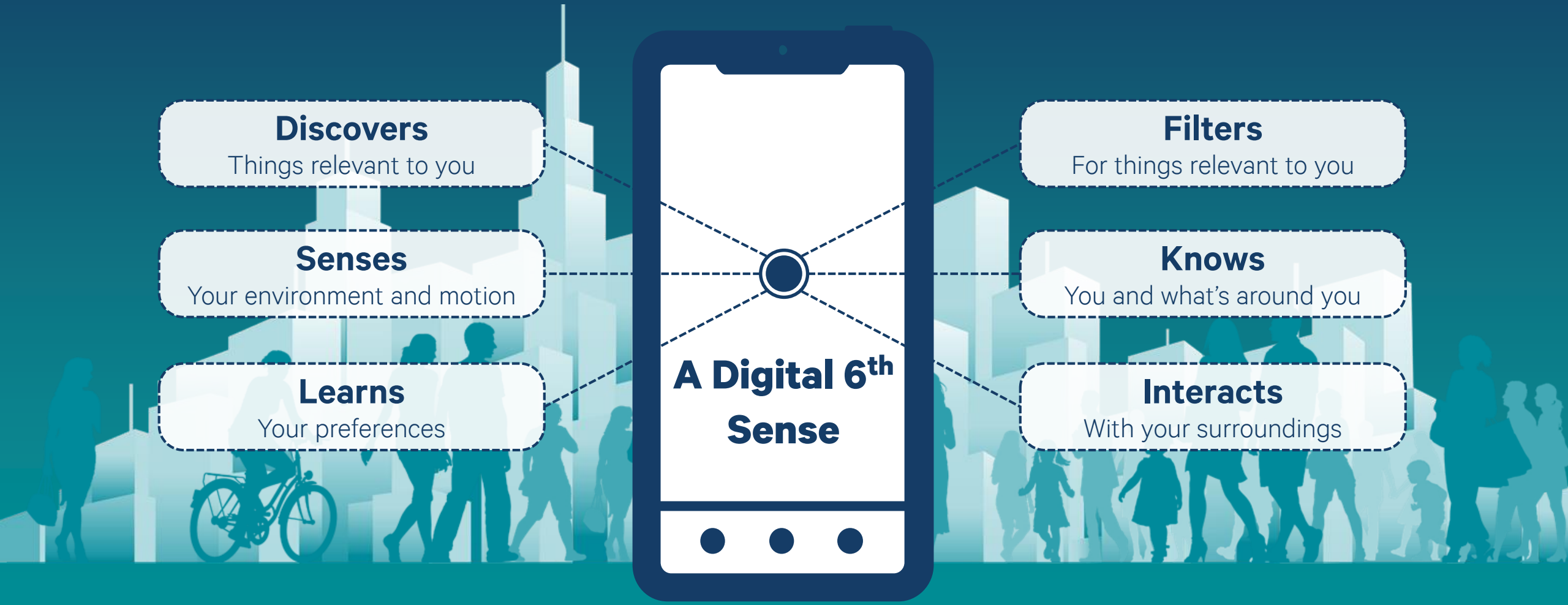
LTE Direct ecosystem implementation underway – standardized in 3GPP R12

Operator trials ongoing; app developers testing innovative use cases today with LTE Direct Trial SDK[1]

1 LTE Direct Trial SDK by Qualcomm Technologies limited availability through ltedirect.qualcomm.com

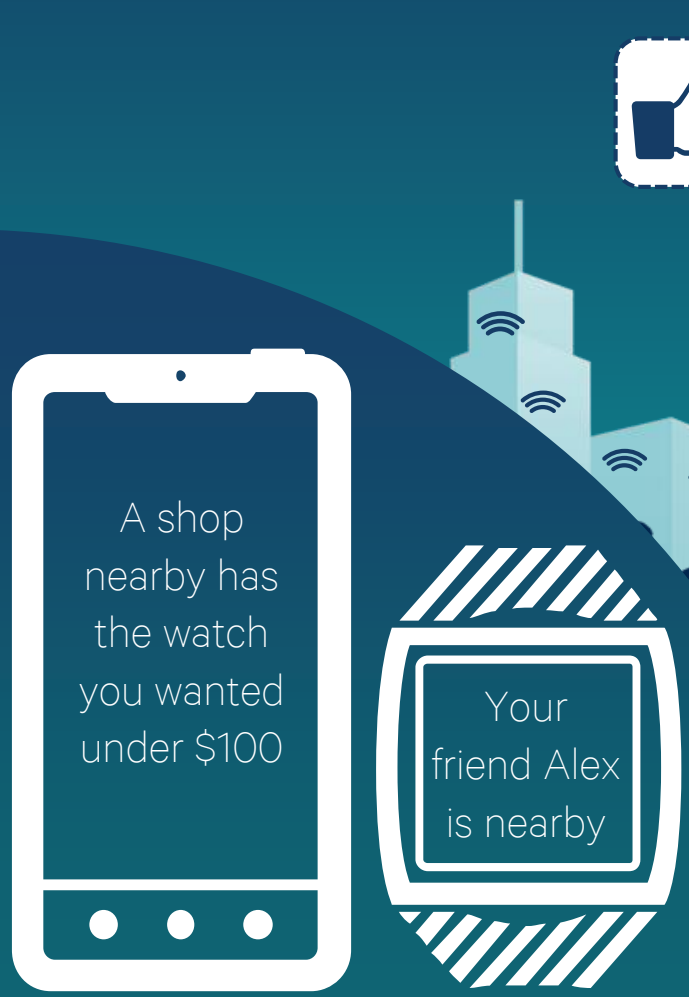
The next generation mobile services in a hyper-connected world

Mobile devices aware of the user and surroundings, connecting our digital and physical worlds



LTE Direct Proximity Services: Always-on proximal awareness

Enabling users & mobile apps to passively interact with the hyper-connected world



Who's nearby? What's nearby? Is it relevant to me, now?

The always-on proximal discovery challenge

Scaling proximity services for mass consumer adoption

Privacy

Barriers to technologies that continuously track location

Battery Life

Always-on services require continuous proximal discovery

Scale

Long range and high capacity required to expand use cases

Interoperability

Proprietary platforms lead to mobile app silos

Proximal discovery services are expanding the reach of mobile

Utilizing technologies today that either track user's location or proximity to nearby beacons

Location-based app

Tracking user's location and access cloud to identify relevancy

- \+ Unlimited range
- \+ Large install base
- \- Privacy barrier with location tracking
- \- Battery drain from constant network pings
- \- Proprietary platform

Proximity Beacons (BT-LE[2])

Deliver relevant value by notifying nearby users using an associated app

- \+ Privacy sensitive
- \+ Low power consumption
- \+ Indoor support
- \- Limited range – 10s of meters
- \- Limited capacity that doesn't scale
- \- Proprietary platform

>$7B total M&A activity in proximal discovery services in 2013[1]

1 Source: BIA/Kelsey, May '13; 2 Bluetooth® Smart (Low Energy) feature as part of the Bluetooth Core Specification version 4.0 and higher

Scaling up proximity services for mass consumer adoption

Location-based

Centralized Geo-fencing

Poor adoption due to poor battery life, privacy barriers, and mobile app silos

Bluetooth Beacons

Distributed Geo-fencing

Gaining traction across limited use cases due to Bluetooth range and capacity, plus mobile app silos continue

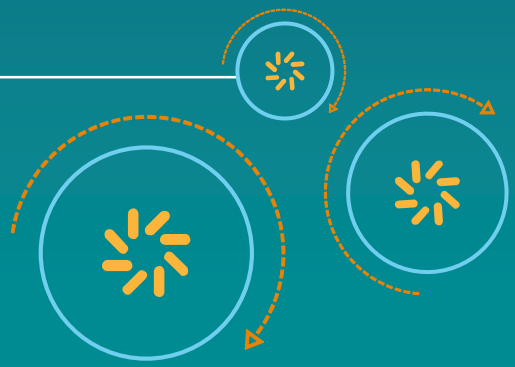
LTE Proximity Services

Device-to-Device Discovery

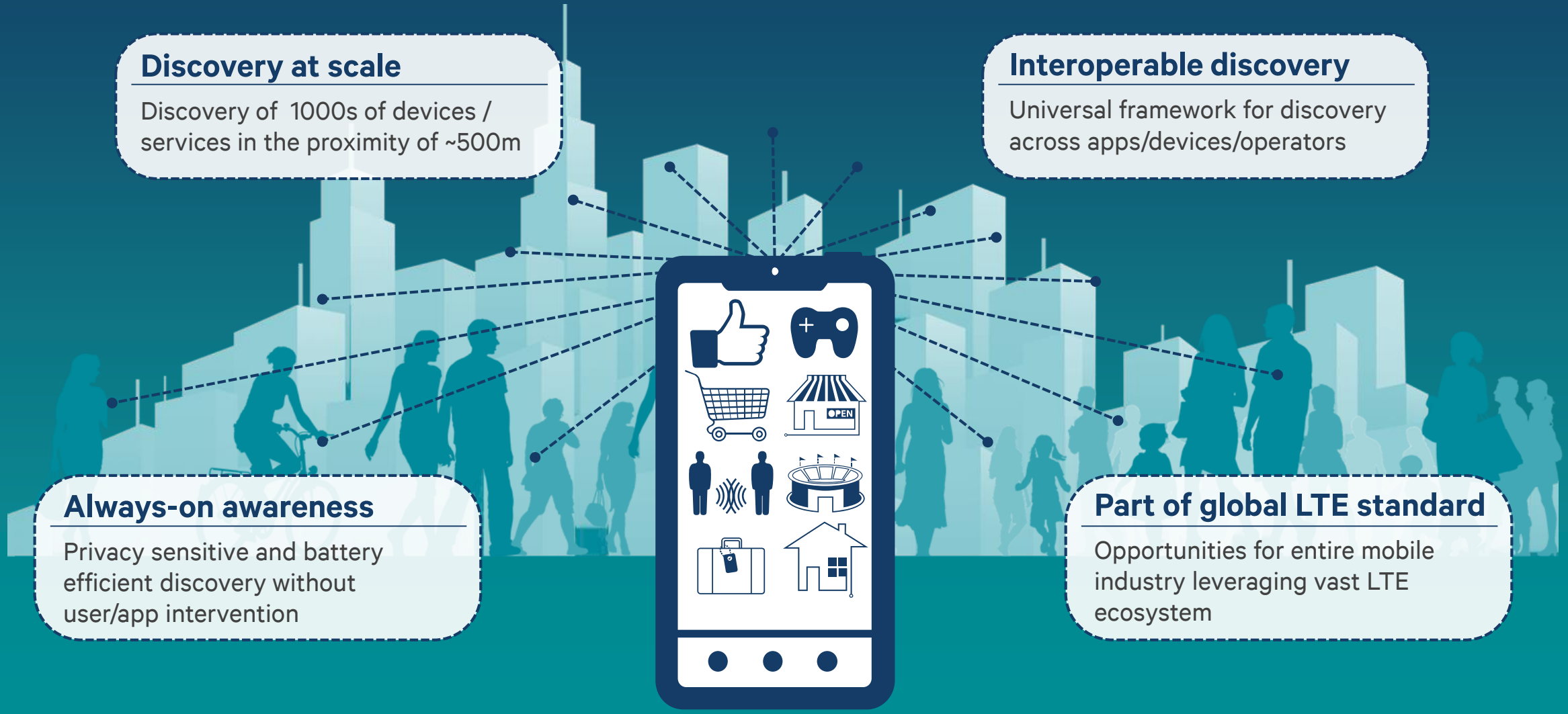
The path to mass adoption across a wide range of use cases with discovery that is:

- Battery efficient and privacy sensitive
- ~10x the range of Bluetooth
- Scalable to 1000s of devices/service
- Interoperable across mobile apps

LTE Direct is a device-to-device technology required to scale up from today's proximal discovery solutions



LTE Direct is solving the always-on proximal discovery challenge



Discovery at scale

Discovery of 1000s of devices / services in the proximity of ~500m

Interoperable discovery

Universal framework for discovery across apps/devices/operators

Always-on awareness

Privacy sensitive and battery efficient discovery without user/app intervention

Part of global LTE standard

Opportunities for entire mobile industry leveraging vast LTE ecosystem

Discovery with unparalleled scalability and capacity

LTE Direct enables broader set of use cases than other device-to-device technologies

	BT-LE	LTE Direct
Capacity	Hundreds	Thousands
Range (m)	~50 m	~500 m
Active Duration (ms)[1]	~4000 ms	~75 ms

Proximal discovery at scale

1 Source Qualcomm Technologies simulations; Assumptions: outdoor deployment model (e.g. Farmer's market), Ped A channel model, ITU-1411 pathloss mode, Carrier frequency of 2 GHz for LTE Direct / 2.4 GHz for BT-LE, System bandwidth of 10 MHz FDD for LTE Direct / 2 MHz for BT-LE, LTE Direct protocol implementation of 75 subframes every 18 seconds, BT-LE beacon protocol implementation of advertising for 1.518 ms every 1.20 s with <20% collision / scanning for 256 ms every 1.28 s

Battery efficient and privacy sensitive always-on awareness

LTE Direct provides enhanced user experience over location-based solutions

Privacy sensitive

Devices do not need to reveal their identity or allow location tracking, thus minimizing privacy barriers

Battery efficiency

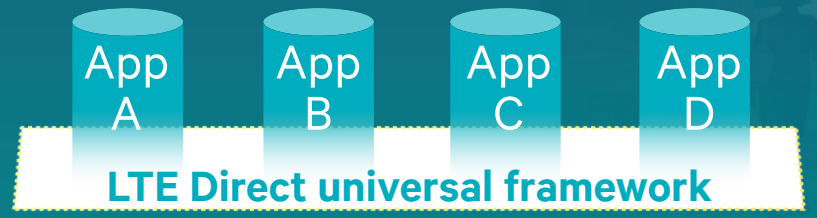
Determining relevancy is done at the device level eliminating battery inefficient network pings

Autonomous

Continuously and passively proximal discovery of relevant value without user or app intervention

LTE Direct provides interoperable discovery

Vastly expanding the reach and value of proximal discovery for mobile app developers



Universal framework for discovery across apps, devices, operators

Example: Digital Out-of-Home personalizing content on digital signs based on input from audience interests/affinities

LTE Direct leverages the global LTE ecosystem

Part of 3GPP Release 12

Common global standard

Support for paired (FDD) and unpaired (TDD) spectrum

Vibrant, global ecosystem

390+ Networks
in 135+ countries

2,900+ Devices
from 250+ vendors

Source: GSA (www.gsacom.com) – April 2015 for networks and Feb 2015 for devices

We must make best use of all technologies for proximity services

Location-based

User-initiated search (plus navigation)

Enhance relevancy of search results through location tracking with unlimited range

LTE Direct

Always-on device-to-device proximal discovery

Privacy sensitive and battery efficient discovery of 1000s of devices / services in the proximity of ~500m

Proximity beacons

Micro-location awareness and geo-fencing

Engage customers in close proximity (~50m) with relevant, timely, and personalized content

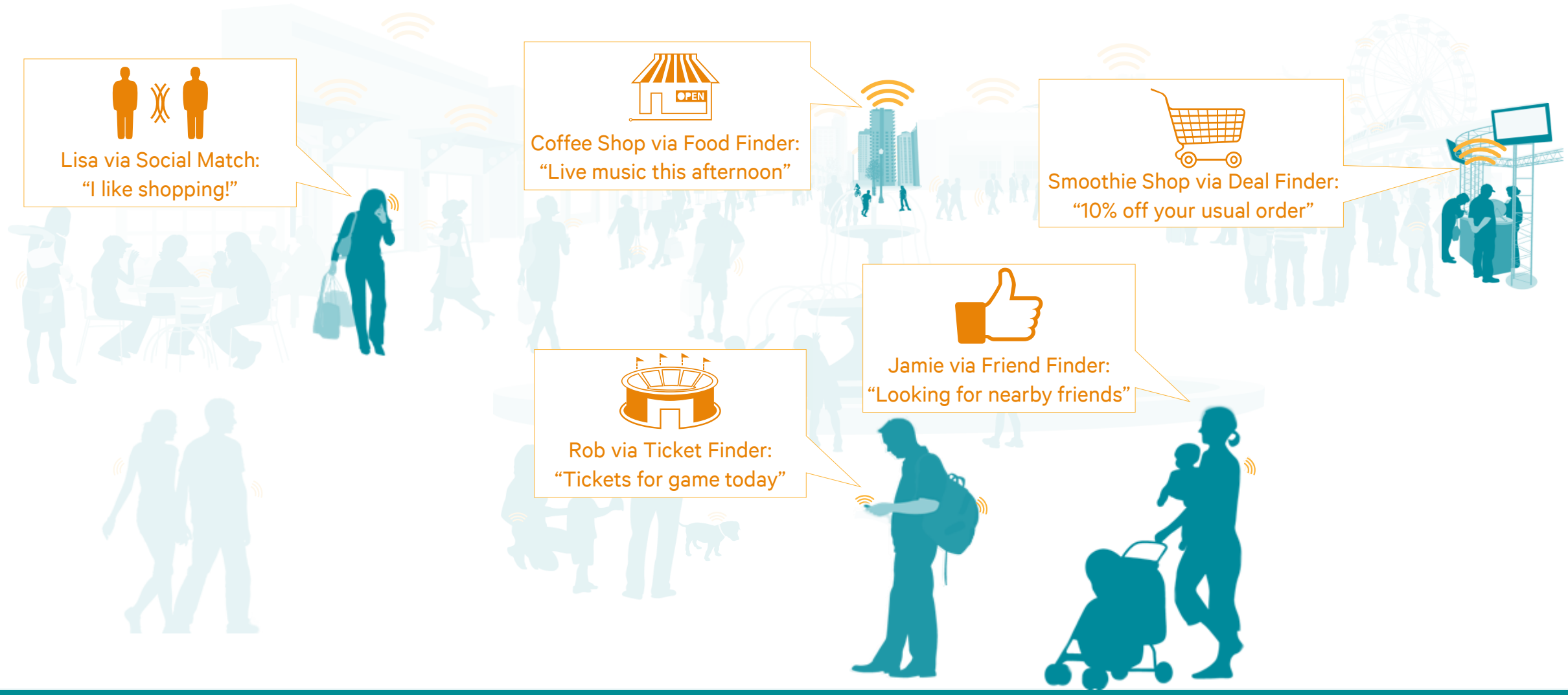
LTE Direct provides privacy sensitive and battery efficient discovery at scale and range

How does it work?

LTE Direct: A day out at the shopping center

LTE Direct is a device-to-device proximal discovery technology

All devices can broadcast needs and services via “expressions”



Services are efficiently mapped to Expressions

Public Expressions

- Application agnostic
- Any proximal device can decode expression
- Good for advertising, local “finder” apps, etc.

Private Expressions

- Application specific
- Only proximal devices with “key” can decode expression
- Good for personal identification

Service

Live Music @ Coffee House

Mobile app leverages centrally managed hierarchical mapping[1]

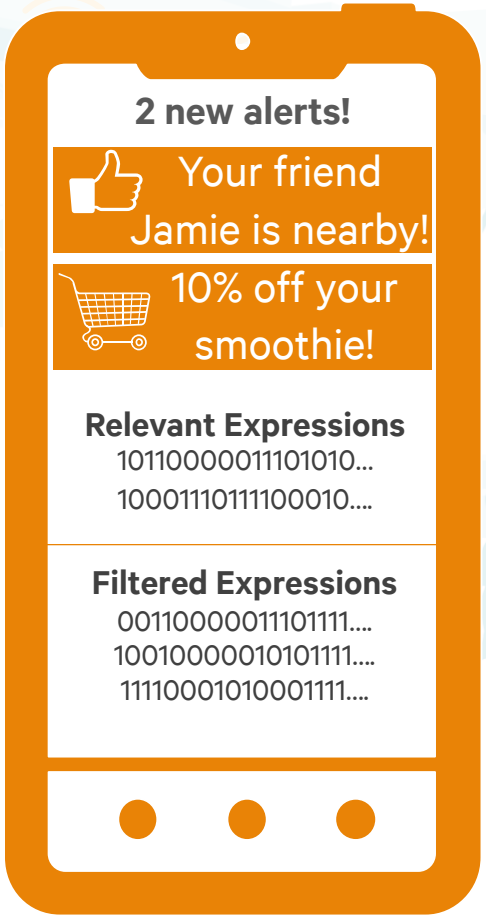
00110000011101111....

128-bit Expression

Note: Private Expression mappings based on a one-way hash function with a private key and permissions controlled via specific apps

Relevance is passively identified with no user/app intervention

Optional metadata
Additional info available following discovery (e.g., street address)

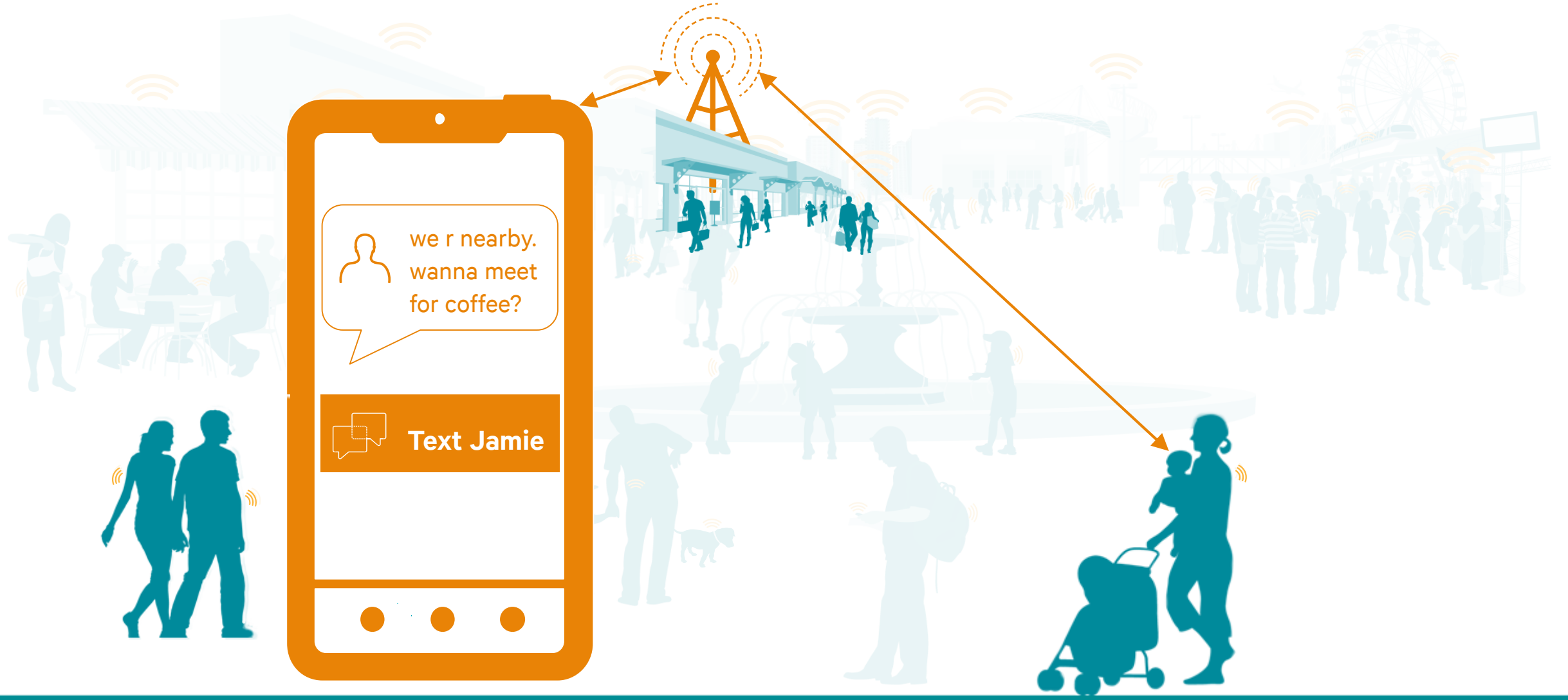


Relevancy is determined at device level

Sale @ Smoothie Shop
10001110111100010....

Jamie @ Friend Finder
10110000011101010...

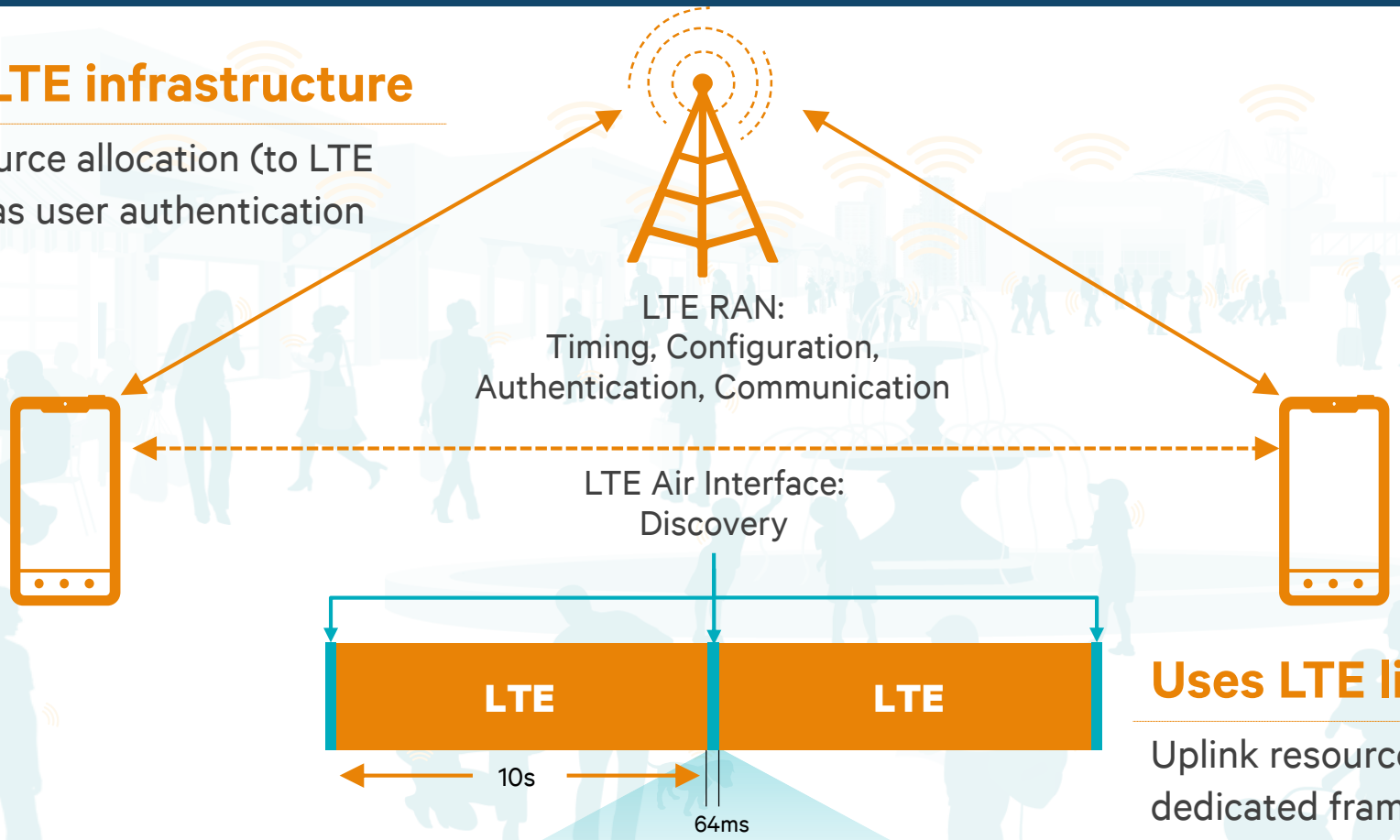
Communication via traditional LTE or Wi-Fi/Wi-Fi Direct



LTE Direct efficiently utilizes LTE spectrum for discovery

Leverages LTE infrastructure

For timing, resource allocation (to LTE Direct), as well as user authentication



Uses LTE licensed spectrum

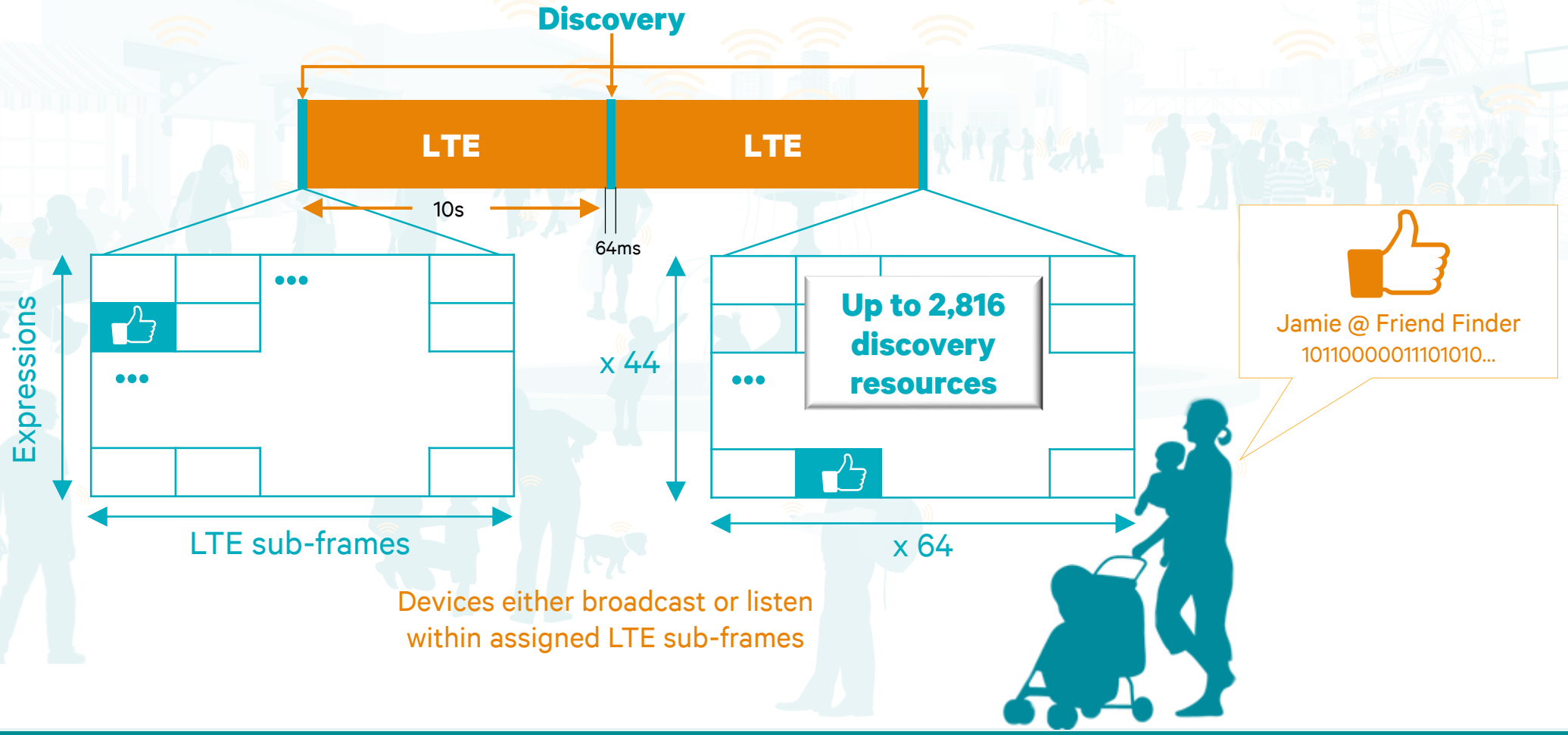
Uplink resources in LTE FDD system or dedicated frames in LTE TDD system

Negligible impact to capacity

Utilizes <1% of uplink resources[1]

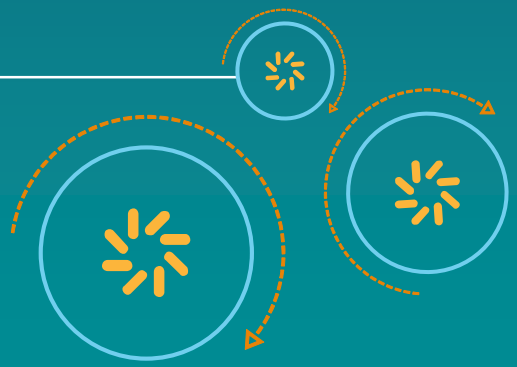
1 Source: Qualcomm simulations; Assumes 20MHz system with ~2,000 expressions

LTE Direct resources are managed by mobile operators



1 Assumptions: 1 Expression = 2 LTE Resource Blocks (RBs); 88 RBs used for discovery in 20MHz FDD system that uses 64 sub-frames @ 1ms each, every 10 seconds

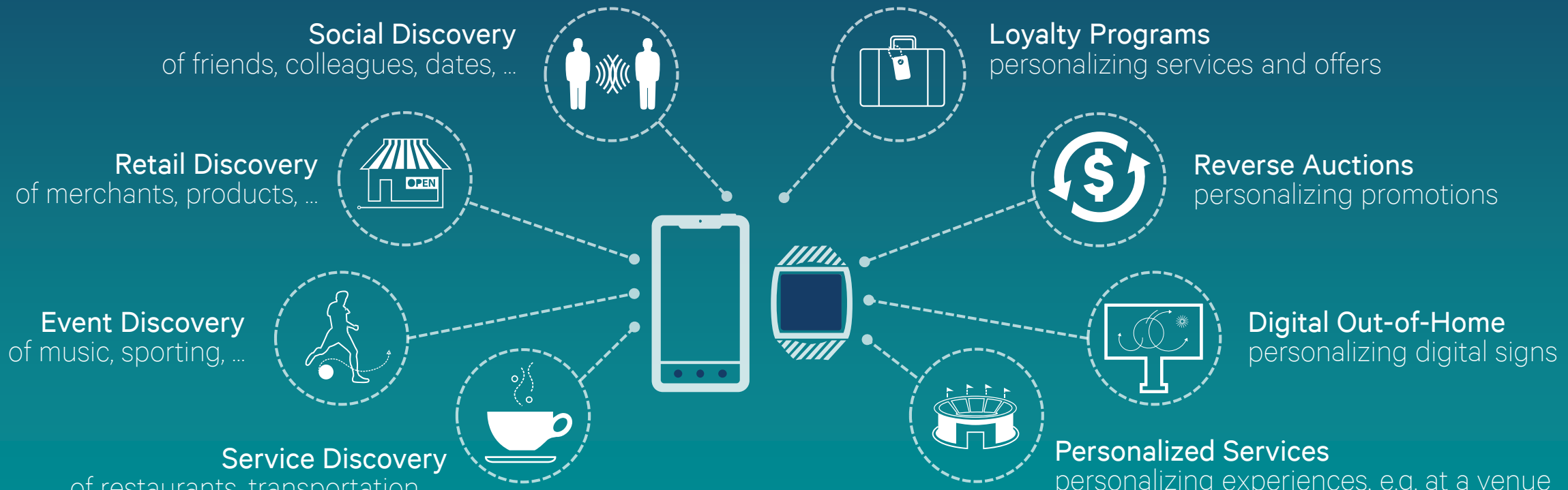
LTE Direct ecosystem implementation is underway creating opportunities for the entire mobile ecosystem



Empowering new experiences across a wide range of use cases

Continuous Discovery
of relevant people, products, services, events

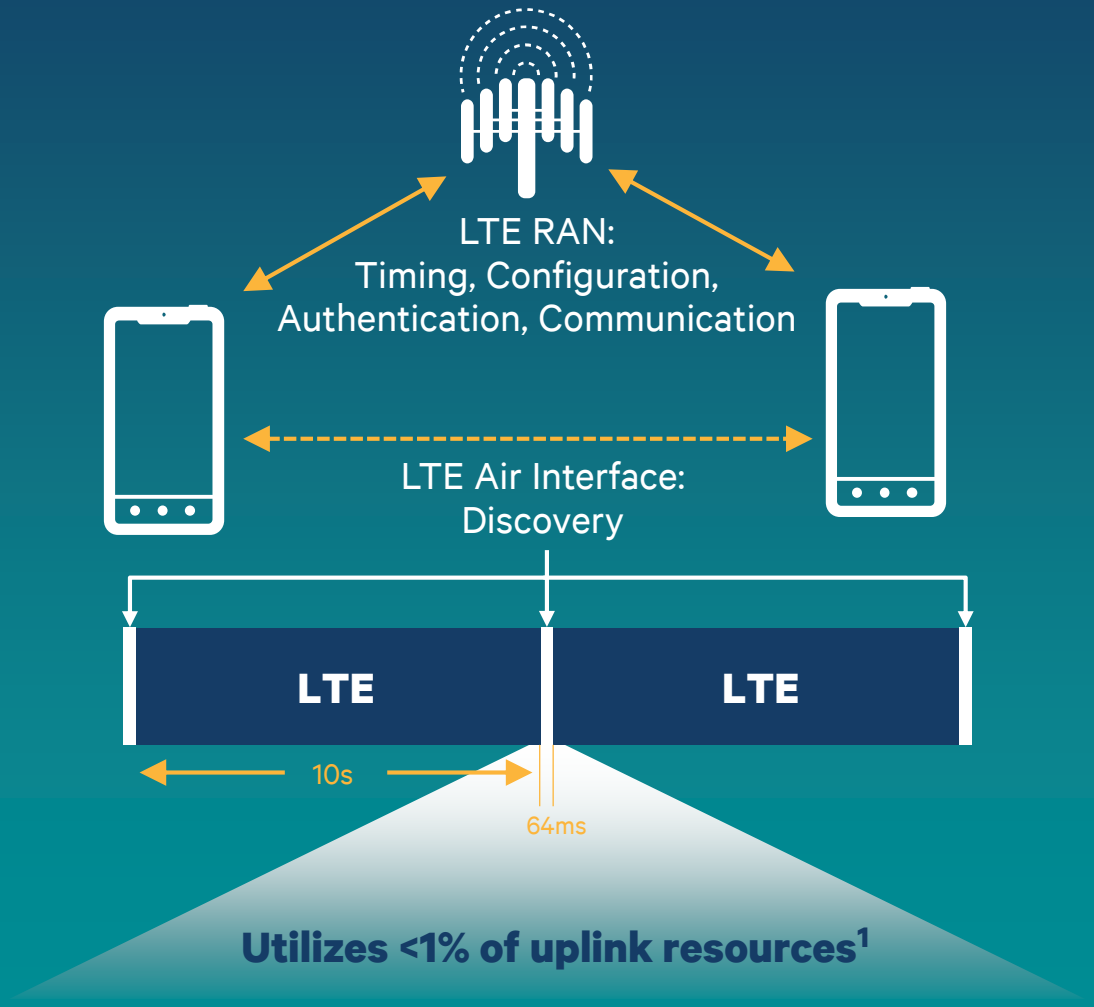
Personalized Interactions
with the user's surroundings and environment



Based on the users interests/affinities

LTE Direct creates opportunities for the entire ecosystem

LTE Direct is managed and monetized by mobile operators



Service Access

Monetize API access to mobile app developers for utilizing LTE Direct Proximity Services

Mobile Advertising

Monetize interest by commercial advertisers to pay for proximity-based consumer notifications

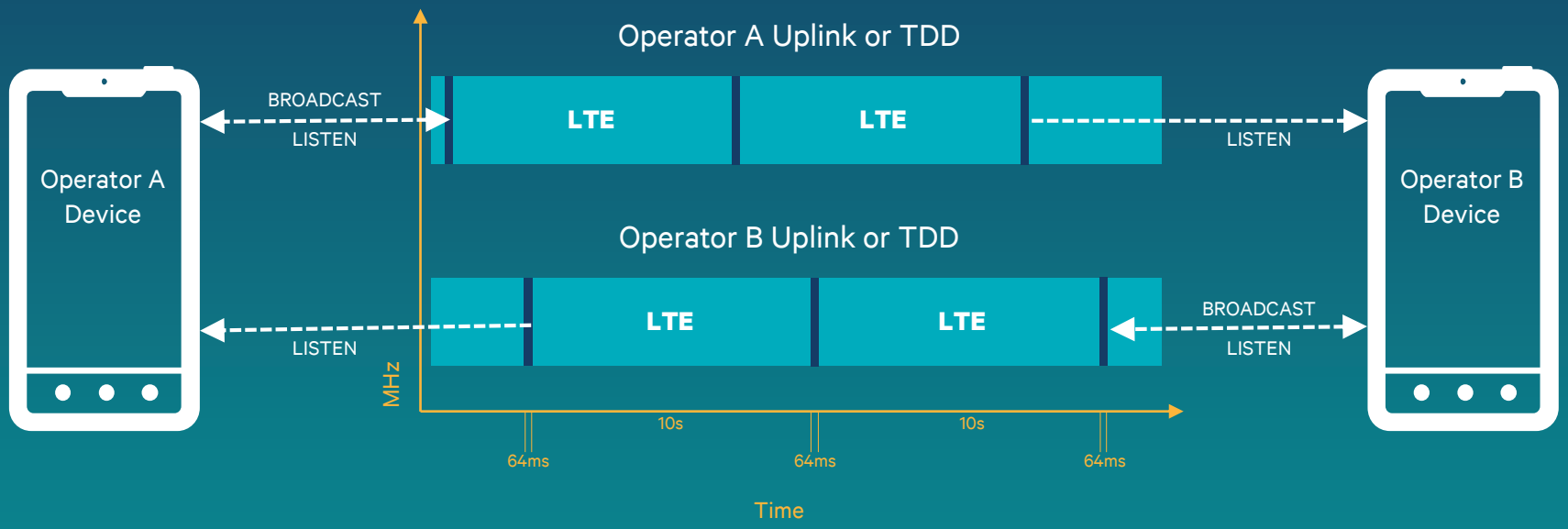
Data Mining

Monetize consumer-approved, anonymized data on consumer interests that are broadcasted and filtered with LTE Direct Proximity Services

1 Source: Qualcomm simulations; Assumes 20MHz system with ~2,000 expressions

Achieving scale requires discovery between mobile operators

Option 1



Broadcast and listen to expressions on their own spectrum
Listen-only on other operator's spectrum

Option 2

All devices in a country/region broadcast and listen to LTE
Direct expressions on the same agreed-upon spectrum band(s)

LTE Direct empowers app providers and OEMs to differentiate

Lead the next generation of mobile proximity services through a differentiated user experience

Discovery at scale

Discovery of 1000s of devices / services in the proximity of ~500m

Always-on awareness

Privacy sensitive and battery efficient discovery without user/app intervention

Interoperable discovery

Universal framework for discovery across apps/devices/operators

Solving the always-on proximal discovery challenge

Implementation of the LTE Direct ecosystem well underway

Standardization

by 3GPP as a feature in Release 12

- System Architecture and RAN specification complete
- RF performance and conformance forecasted to be complete

Operators Trials

launching across multiple regions

- Technical Trials completed with Deutsche Telekom (Germany) & KT Corp. (Korea)
- Large Scale User trials planned in China, US and Japan
- Trials supported by multiple infrastructure vendors and device OEMs

App Developers

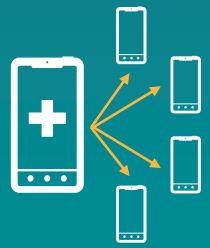
engaging on use case development

- Developing use cases leveraging trial SDK by Qualcomm Technologies
- Early developers include Facebook, Yahoo, Control Group, R/GA, Sacramento Kings, M-87, Compass.To, and more

LTE Direct is evolving to bring new ways to connect & interact

Release 12
D2D platform for consumer and public safety use cases

Discovery of 1000s of devices/services in ~500m



Reliable one-to-many communications (in- and out-of-coverage)*

Release 13
Expanded D2D discovery and D2D communications

More flexible discovery such as out-of-coverage and multi-carrier

Device-to-network relays*

Release 14 and beyond
Multi-hop communication and more use cases

Additional D2D communication capabilities

Proposed for vehicle-to-vehicle (V2V)

* Designed for Public Safety use cases

LTE Advanced is evolving and expanding into new frontiers

Scaling to connect the Internet of Everything

Carrier Aggregation

High performance

Ultra efficient

Cat-0, LTE-M

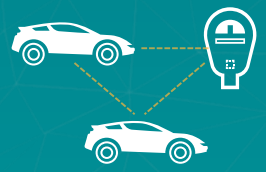
Bringing new ways to connect & interact

Evolving the LTE Direct Platform

Device-to-Device

Multi-hop

Vehicle-to-Vehicle / Infrastructure



Empowering new classes of services

Mission-critical control

LTE ULL

Broadcast

LTE Broadcast

Discovery

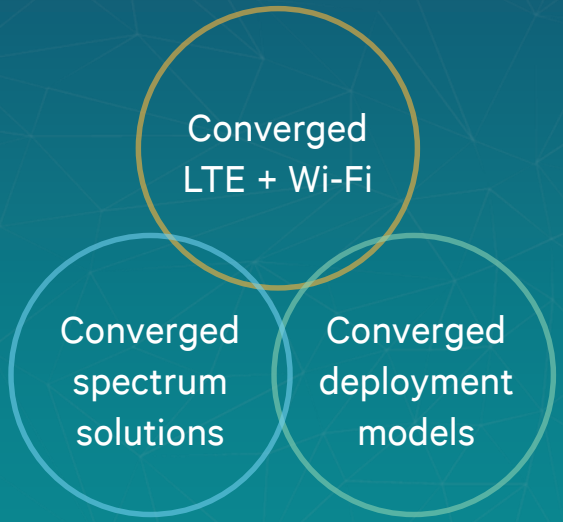
LTE Direct Proximity

Public Safety

LTE Direct MCPTT

Creating a converged connectivity platform

Link aggregation



LTE-U and LSA

Neighborhood small cell

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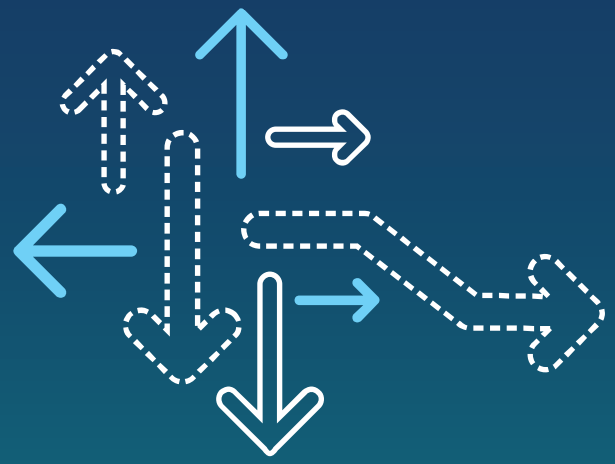
Questions? - Connect with Us



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