December 2024

All about
REDCAP
– will it be a boon to 5G and IoT?

*by James Blackman
and Juan Pedro Tomás
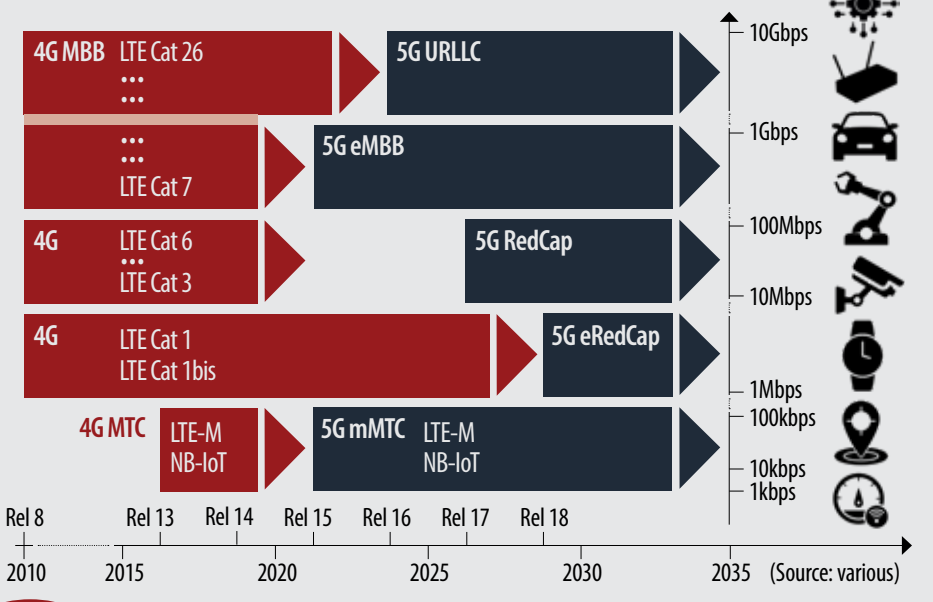RCR Wireless News*

QUECTEL

Let's start with some stats. The broad internet-of-things (IoT) market will drive demand for reduced-capability (RedCap) 5G, and even more for further-reduced ('enhanced') RedCap (eRedCap) technology, to the tune of almost a billion connections by 2030. This is from analyst house Omdia, which says the total will surge upwards at a compound annual rate (CAGR) of 66 percent in the period, to reach 963.5 million connections by 2030. The firm says the "gradual phase-out" of LTE (4G) over the next decade will see a migration of IoT applications onto 5G networks, with LTE-based Cat-4 and Cat-1 giving way to RedCap and eRedCap in particular. "Companies across various sectors are beginning to deploy this technology, anticipating its wide-scale adoption in the coming years," it writes.

Omdia, with a new report about the "growing influence of 5G on IoT", has been bullish on RedCap for years, going so far as to call it the "big missing piece of the 5G IoT puzzle". But if we switch from airtime connections to hardware units, and we switch analyst houses in the process (and permit some discrepancy between market sizings and forecasts), then the picture looks different. ABI Research is more cautious, it seems. By contrast, ABI Research says total shipments of RedCap-based IoT hardware modules, offering 5G-based alternatives to midrange LTE Cat-4 and LTE Cat-6 units, will top 80 million over the next five years, in the period to 2029. Which is a much lower forecast, clearly; even if the Omdia view considers the consumer market as well, the delta looks big.

Total cumulative revenues from the sale of RedCap IoT modules will reach $1.2 billion in the period, it says. ABI Research, with its own report, says shipments of eRedCap IoT modules, offering 5G alternatives to lower-range LTE-Cat-1 and Cat-1bis (a single-antenna version of LTE Cat-1) hardware, offer an even "greater market opportunity". Seventy-one percent of all RedCap modules (56 million

RedCap's place in new 5G hierarchy

Filling a gap – RedCap and eRedCap technology, specified by 3Gpp in releases 17 and 18 of the 5G NR standard, sit between enhanced mobile broadband (eMBB; release 15) and massive machine-type comms (mMTC), based on LTE and made 5G-compatible in release 15; they follow from LTE-based Cat-6 through to Cat-1.

out of the 80 million forecast) will be based on eRedCap, it reckons; the rest (29 percent, 23 million units) will be on straight Release-17 level RedCap. Sales of slimmed-down eRedCap modules, available later in the cycle, will reach $615 million, from 2024 to 2029.

As context, here, Release 17 of the 5G NR standard included provision for IoT sensors to connect to 5G with significantly reduced network – and therefore hardware, and therefore cost-linked – capabilities. This specification, previously called 'NR-Light', now called RedCap, sits provisionally between low-power IoT and standard-performance broadband, defined as massive machine-type comms (mMTC) and enhanced mobile broadband

963m
total RedCap connections by 2030; growing 60% per annum – Omdia

80m
shipments of RedCap IoT modules, to 2029 – ABI Research

71%
of RedCap IoT shipments to be on eRedCap – ABI Research

(eMBB) in the 5G NR power hierarchy, respectively. It sits two rungs below ultra-reliable low-latency comms (URLLC) for elite critical-level performance (see above, and page XX).

Release 18 introduces eRedCap to offer further reduced capabilities, and lower costs, which puts it in range of low-power wide-area (LPWA) IoT applications, as captured in LTE by the mMTC-style twin-technologies NB-IoT and LTE-M. As above, ABI Research says RedCap will migrate midrange LTE-based IoT devices, using older category-four and -six (Cat-4 and Cat-6) versions of 4G, onto 5G networks. Meanwhile, eRedCap, reducing complexity further to "unlock another sizeable market", will migrate the higher-end of the LTE-based LPWA IoT market, as earmarked for NB-IoT and LTE-M, but often using LTE-Cat-1 and Cat-1bis.

All of which makes RedCap/eRedCap "particularly interesting for IoT", says Jonathan Budd, industry analyst at ABI Research.

He explains: "5G RedCap is a series of network and device optimisations that strip back device complexity… [and provide] an affordable pathway to 5G for IoT device OEMs that do not require the full spectrum of 5G capabilities." Indeed, RedCap devices feature a simplified architecture compared to fully-fledged 5G units. "They have a reduced number – a max of two – receive-antenna branches, only one transmit-antenna branch, and offer lower maximum bandwidths," comments Richard Cockle, head of IoT (and other things) at the GSMA.

Cooke adds: "Additionally, they do not support carrier aggregation or dual connectivity. These simplifications significantly reduce device complexity and cost while still providing adequate performance for many IoT use cases." All of which brings 5G into the scope of (cheap and old, and even reduced-capability) LTE technologies. Budd notes: "The mid-tier LTE categories have proven valuable in connecting IoT devices; RedCap delivers LTE-equivalent throughput performance, with assurance of network longevity into the 5G era. As a replacement for LTE Cat-1 and Cat-1bis, eRedCap will be widely applicable [for] devices across the IoT application landscape."

FRAGMENTS AND FORECASTS

It is easy to understand the excitement, if only to simplify a mess of fragmented LTE choices for IoT. Igor Černjava, product manager at China-based IoT module maker Quectel, positions RedCap in the middle of the 3GPP venn diagram of 5G capabilities (see page XX), between mMTC, eMBB, and URLLC; it somehow unites a bunch of IoT outlets for these functions in a cheaper two-tier technology, he says. "RedCap is designed to offer a middle ground with reduced complexity and lower power consumption compared to traditional 5G. This makes it better suited for IoT applications that require constant connectivity but don't need the full bandwidth or latency advantages of 5G."

He goes on: "It can standardise connectivity for a wide range of IoT devices, which currently operate on diverse and often in-

"RedCap offers a middle ground… It is better suited for IoT apps that require constant connectivity but don't need the full bandwidth advantages of 5G. It can standardise connectivity for a wide range of IoT devices, which currently operate on diverse and often incompatible technologies."

Igor Černjava,
Product Manager,
Quectel Wireless Solutions

compatible technologies. By providing a common platform with scalable connectivity options, it reduces the need for multiple, fragmented solutions." This promise to consolidate a fragmented cellular IoT market is an important part of its appeal. Speaking on the webinar that attends this report, Jan Sulaiman, global director for solution engineering at virtual network operator (MVNO) 1NCE, explains: "In the long run, there will be gains for mobile operators, of course, because it offers a path to consolidate their

networks and simplify their infrastructure."

The cellular IoT market needs a bump, it appears. The global market for cellular IoT modules slipped by around two percent in terms of annual shipment volumes in 2023, compared to 2022. It was the first time cellular IoT sales have shrunk over a 12-month period, according to Counterpoint Research (also with a new report; but without hard numbers). It cites supply chain disruption and reduced demand from certain enterprise and industrial IoT sectors. To an extent, all hopes are pinned on RedCap. The market will have stabilised by the end of 2024, it says, and see "substantial growth" in 2025 on the back of "widespread adoption" of 5G, and notably 5G-based RedCap, across all IoT categories.

Mass adoption of RedCap for mid-tier cellular IoT applications begins now – from this year (2024), says Omdia; starting in China. The arrival of RedCap will help to drive overall cellular IoT connections to 5.4 billion in 2030 representing a rise of around 70 percent compared to 2023, it forecasts. Alongside, it suggests, old-school 2G/3G-based IoT connections will vanish, effectively, by 2027; 4G/LTE-based IoT connections will continue to dominate, going from around 2.6 billion in 2023 to 3.2 billion in 2030 (but from 82 percent to 60 percent of the total); and 5G-based IoT will reach about 1.2 billion in 2030. This latter forecast suggests 5G will comprise around 22 percent of the total cellular IoT market – from virtually nothing in 2023.

Note, these are estimates based on a reading of the Omdia graph below – which do not make much sense in the context of Omdia's latest (newer) billion-volume Red-Cap-forecast, which says 5G-based RedCap/eRedCap, alone, will contribute almost 20 percent of cellular IoT sales in the period. Such is the tangle of finger-in-the-air forecasts, periodically modified by their authors, apparently contradicted by their rivals. No matter; the point is there is considerable excitement in the figures. Indeed, hype around RedCap is impacting the IoT vendor community in the way that its parent technology, 5G, has impacted most of the

mobile market – to the point expectations among customers are unrealistic, and LTE-based IoT solutions have become a harder sell. That is the word on the street, anyway.

But Omdia says RedCap will find its groove, starting this year, as a mid-tier 5G-IoT solution to slot below critical-grade URLLC and fully-fledged eMBB comms. "It will enable futureproofing of devices as the industry anticipates the eventual phase-out of 4G beyond the year 2030," it writes. Alexander Thompson, senior analyst for IoT at Omdia, says: "In just a year since the first [RedCap] module launches, we've already seen small-scale deployments and trials begin to take shape." It predicts eRedCap will follow the path of RedCap, starting to filter into the market in late 2024, gathering pace in mid-2025 – but "with a slight delay of a year or two, helping bridge the gap as industries transition from 4G to 5G", it says.

The signs are there; you can see it in recent product releases and news headlines. T-Mobile US has just (October 2024) launched a RedCap USB-C dongle, called LINKPORT IK511, from manufacturer TCL. It features the Snapdragon X35 5G Modem-RF System, and offers peak data rates of 220Mbps – presented as "significantly faster" than existing LTE Cat-4 connections, and offered with slicing and various carrier-specific airtime products. It is the only commercially available 5G RedCap device currently in North America, the carrier said.

Quectel announced commercial availability of its new sub-6 GHz RG255C-GL module in the summer (July), based on Qualcomm's Snapdragon X35 baseband chipset, and offered in a land-grid array (LGA; surface-mount) for integrated circuits (ICs), with support besides for LTE Cat-4, plus sundry satellite positioning technologies. It is geared for customer premises equipment (CPE), routers, gateways, and industrial PDAs, it suggests – with "nearly all" mainstream carriers worldwide. But most of the action is around testing. In recent months, AT&T, BT Group, China Mobile, China Telecom, China Unicom, Optus, SK Telecom, and Verizon have all worked on RedCad capabilities with equipment suppliers.
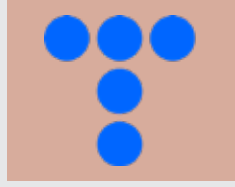
Top Red-Cap MNOs

Leading carriers – in no order, from top to bottom: China Mobile, Vodafone, China Telecom, T-Mobile US, Du, China Unicom, Telefónica, and e& are among a (relatuvely short) list of mobile operators to have either launched or tested RedCap in their markets. One way or another, 31 operators in 22 markets (including eight out of 15 in Asia Pacific) have confirmed strategies with RedCap; the three Chinese operators, shown left, have all launched RedCap services. But there are 60-odd 5G SA networks, and 320-odd 5G SA/NSA networks on the planet – and so there is a long way to go to make RedCap a contender as an LTE replacement for for global IoT business.

O2 Telefónica was trialling RedCap in its network in Munich, in Germany, back in April. "We are creating the technical pre-requisites for connecting millions of devices efficiently and cost-effectively. It will be crucial to see how the market, the product world and digital applications develop," said Mallik Rao, chief technology and information officer of O2 Telefónica, at the time. In July, Ericsson ran "end-to-end" tests of its RedCap software on Emirati-based operator e&'s network in the UAE – as the first implementation of its RedCap solution in a commercial network in the Middle East and Africa (MEA) region. EchoStar, Mavenir, and Qualcomm were doing the same in June, on the Boost Mobile network, billed as the first validation of RedCap in an open virtualized RAN (open vRAN) system.

EchoStar talked up the prospect of "tailored connectivity solutions to better meet the needs of customers across all industry segments". Mavenir talked about RedCap in the context of "max- imising paths to 5G revenue through ubiquitous device connectivity". Meanwhile, Samsung has tested RedCap data sessions over virtualized RAN in a research lab in South Korea, using its vRAN 3.0 software and open RAN radios, together with MediaTek's M60 modem and testing platform. The main focus, apart from virtual/open RAN interoperability, was on two key energy-efficiency features, called paging early indication (PEI) and extended discontinuous reception (eDRX). They work on RedCap, say the tests.

One of the first – the sub-6 GHz RedCap RG255C-GL module from Quectel

But the surest sign that the technology is ready is that mobile operators have standalone 5G (5G SA) networks deployed across the planet, and that they are also deploying RedCap on top of them. Because RedCap rides on 5G SA; one begets the other – if the other is deemed, ultimately, to

make business sense for mobile operators. The GSMA is in no doubt, of course. Speaking on the same webinar session, Christina Patsioura, lead analyst for IoT and enterprise at GSMA Intelligence, comments: "We know it will be turned on, eventually. [But] operators have to determine the timing of their launches. They have to decide to invest in and support relevant use cases… 5G SA deployments precede RedCap deployments."

In August, the GSMA said operators in 15 countries were already investing in RedCap technology through trials and deployments. "Asia Pacific is leading in trials and deployments, with about half of the 15 countries located in this region," it said. On the same webinar session, in November, GSMA Intelligence suggests 31 operators in 22 markets had "either commercially deployed or announced plans [to deploy], or are currently testing, RedCap technology". Sahil Itkan, manager at GSMA Intelligence, qualified the statement further; 22 out of the 31 are in-test, it seems. "That includes major operators in the US who are soon to deploy it commercially," he said.

He summed up: "Momentum continues to grow, promising transformative impact across various industries… The RedCap ecosystem [of equipment vendors, chipset makers, module makers] is active... The range of use cases is diverse… Priority use cases will depend on the demand trends in each individual market." But does 31 – or 22 or 15 – networks constitute real momentum? Well, yes, probably, given RedCap chipsets and modules are only just available, and that there are only 60-odd 5G SA deployments globally, according to Ericsson's last (Q2) 'mobility report'.

Only three countries – China, the US, and Kuwait – have deployed the technology for proper use, with China at the forefront. China's three largest operators are already offering RedCap for customers. At MWC

31
mobile operators in 22 countries have deployed, scheduled, or tested RedCap – GSMA

60
5G SA networks, needed for RedCap, have been deployed globally – GSMA

320
5G NSA + SA networks globally –suggesting the size of the total operator market for RedCap

Image: 123rf

"RedCap has attracted the attention of carriers, equipment manufacturers and ecosystem partners... China has launched the first large-scale commercial RedCap [network]… In the next three years, it will... breakthroughs in the [range of] hundreds of millions of connections, and integrate into many industries."

Xiang Fang,
Vice President,
Wireless Network Products,
Huawei

Shanghai in June, Xiang Fang, vice president of Huawei's wireless network product line, said the whole market has pricked up its ears, and rolled up its sleeves. Fang said: "RedCap has attracted the attention of car-

riers, industry customers, equipment manufacturers and ecosystem partners since its inception. Currently, China has launched the first large-scale commercial use of Red-Cap… In the next three years, RedCap will gradually make breakthroughs in the [range of] 100 millions of connections, and gradually integrate into many industries and consumer application scenarios."

The ecosystem is ready for commercial production, he said, with many IoT industry partners having released RedCap products. "It is estimated that the number of RedCap terminals will exceed 100 by the end of 2024," said Fang. But really, the fact there are only 60 SA networks, globally – out of 320-odd 5G (SA/NSA) networks in total – should be more of a concern, perhaps. Budd at ABI Research remarks: "RedCap can only be enabled with 5G SA. Without extensive 5G SA coverage, device OEMs are unlikely to see the value in migrating… Operators need to ensure 5G SA networks are not just confined to metro centres, but expanded to remote locations for things like metering and asset tracking."

Scaling RedCap will also take time, says the GSMA, noting the early trials and de-

ployments focus on various IoT use cases. Which is another way of saying the telecoms market is skirting around the issue, figuring out whether it can actually make any money from RedCap. Černjava at Quectel says the end-user market is growing familiar with RedCap, but that more work needs to be done to explain how RedCap (another cellular technology!) helps to solve business and connectivity challenges. He says: "Many industries understand the potential of 5G but may not be aware of how RedCap addresses their needs for cost-effective, reliable, and low-power connectivity. Continued education and demonstration of real-world use cases are necessary to drive adoption."

Cockle at the GSMA, maintains the standard view about RedCap as a NR-native driver for mid-range IoT cases, and eRedCap as a driver of lower-end LPWA-style cases, which will eventually usurp NB-IoT and LTE-M, as well – as hardware prices come down (drastically), NR functions like slicing become popular (even requisite), and LTE/4G networks are eventually retired anyway (to leave no cellular alternative for even battery-powered IoT). 3GPP defines three key scenarios for RedCap: surveillance cameras, smart wearables, and industrial sensors. Huawei has been pushing these 3GPP definitions in tests. "Most verticals can benefit from RedCap," said Fang in June. Cockle, like everyone, also cites fixed-wireless access (FWA) units among the key candidates for new RedCap/eRedCap chips.

He lists smart-home, smart-healthcare, smart-grid, smart-city, and smart-factory (smart-everything, right?) settings as likely candidate venues. Černjava at Quectel lists the same apps and industries: smartwatches, fitness trackers, medical devices, industrial sensors, and sundry trackers and monitors for utility, transport, and logistics companies. Cockle calls RedCap "pivotal" and "revolutionary". He says: "Smart cities are a cornerstone of modern urban development, with RedCap playing a pivotal role. By connecting diverse smart devices and sensors, [it] enables real-time monitoring and management of transportation, environment, energy and more. In smart manu-

"In smart cities... [RedCap] enables... monitoring and management of transportation, environment, and energy. In manufacturing, it addresses challenges in efficiency, control, and transformation by providing stable, efficient connectivity for real-time data transmission and remote control."

Richard Cockle,
Global Head of IoT,
Identity and Big Data,
GSMA

Image: 123rf

facturing, 5G RedCap is revolutionary."

He goes on: "It addresses challenges in efficiency, cost control, and intelligent transformation by providing stable, efficient connectivity for real-time data transmission and remote equipment control. This significantly boosts production efficiency and reduces downtime." Module maker Quectel says the same; Igor Černjava, product manager at the firm, comments: "For smart cities, [RedCap] enables scalable deployment of sensors and devices for public safety, energy management, and transportation systems." RedCap will also support large-scale machine-to-machine comms, as well, to drive automation and intelligence of factories, and other industrial sites. It will evolve with 5G-Advanced to support for even-more cost-efficient and power-sensitive IoT apps, says Cockle.

This Industry 4.0 angle is important. Černjava at Quectel says: "In industrial scenarios, RedCap will enhance process automation, predictive maintenance, and real-time monitoring." But market forces also dictate that RedCap is in high demand. A number of markets are offering private spectrum for private networks on the proviso that enterprises deploy 5G, and not LTE/4G. Which means they have no recourse, presently, without reduced-price RedCap, for 'massive'-scale cellular IoT sensor deployments – which might be served by LTE-based NB-IoT and LTE-M, in theory, if regulators permitted, but are more often delivered by private LoRaWAN (and sometimes Sigfox or MIOTY) networks, or else just Bluetooth, Wi-Fi, and sundry proprietary 802.15.x technologies.

COMPLEXITIES OF COST

Apart from SA-network availability, in both public and private setups, and availability of compatible IoT devices, particularly in the industrial sector, the biggest obstacle for smooth and rapid adoption of RedCap is price. "RedCap helps lower the cost of adopting 5G applications while maintaining good coverage quality and performance," says Fang at Huawei. His firm reck-

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# Will RedCap save cellular IoT? The skinny on the (skinny) 5G tech

RedCap fixes a problem for cellular-IoT, as a cut-down 5G-based tech for massive IoT – on on paper, anyway

Will 5G-based RedCap save cellular IoT as a commercially-viable globally-standardised (and -available) technology to deliver massive-scale industrial change? Because (if one thing is clear), of all the huff and puff about planet-saving future tech, none has been longer-promised or bigger-hyped than IoT – and the cellular market has so far made a hash of it, while more disjointed and more resourceful non-cellular operatives have swooped in, as well as they have been able.

But before we editorialise any more, and before we get squinty about the small print, we should recap; Release 17 of the 5G NR standard, frozen in June 2022, includes a provision for IoT sensors to connect to 5G with significantly reduced network – and therefore hardware, and therefore cost-linked – capabilities. This new specification, called Reduced Capability (RedCap; previously 'NR-Light'), sits provisionally between mMTC and eMBB in the 5G NR power hierarchy. To add context; it effectively sits two rungs below URLLC, affording the headiest view of IoT comms, in this 3GPP ladder – which is most commonly presented, actually, as three points in a 5G NR family triangle. The thing about these three specification-types, however, is that only two are 5G-native. The twin low-power wide-area (LPWA) technologies underpinning mMTC, the massive (machine-type) IoT segment, are LTE-based, albeit compatible with 5G NR radios.

RedCap, and the new 5G NR venn diagram

Middle ground – as right, RedCap slots between, and crosses between, URLLC, eMBB, and mMTC in the 3GPP feature-mix for its expanding 5G NR family of technologies. As below, its performance characteristics also slot between critical IoT, as served by URLLC (and eMBB to an extent), and massive IoT, as served buntil now only by LTE-based tech.

Sources: Ericsson, 3GPP (top); Qualcomm (bottom)
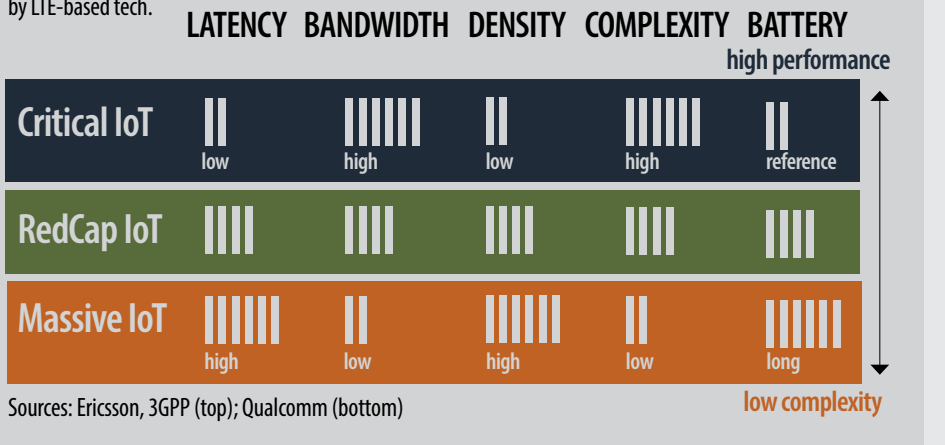
And only these technologies, ultra low-power NB-IoT and 2G/3G-like LTE-M, offer support for stripped-back, dirt-cheap, long-life, mega-scale IoT. So, as it stands, and going forward, cellular IoT needs LTE (including and increasingly, Cat-1 and

Relative performance – versus LTE IoT

	LTE Cat-1bis	LTE Cat-4	RedCap
BANDWIDTH	20 MHz	20 MHz	20 MHz (sub-7 GHz)
DATA RATE (peak; dl/ul)	10/5 Mbps	150/50 Mbps	150/50+ Mbps
DUPLEXING	FD-FDD, TDD	FD-FDD, TDD	HD-FDD, FD-FDD, TDD
TX/RX CHAIN	1 Tx, 1 Rx	1 Tx, 1 Rx	1 or 2 Tx, 1 or 2 Rx
MIMO LAYERS (dl/ul)	1/1	2/1	1 or 2/1
COUPLING LOSS (max)	140 dB	140 dB	140 dB

Massive IoT	Broadband IoT
RedCap IoT	Critical IoT
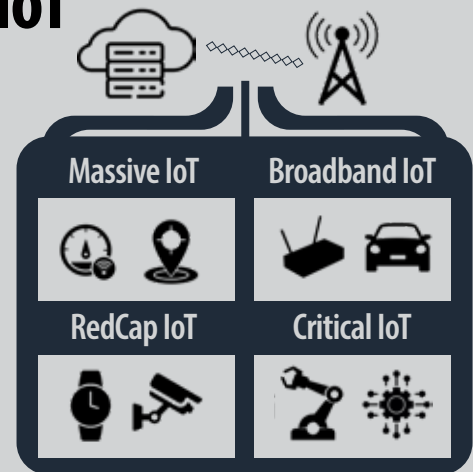
Usurper – from a technical point of view, RedCap is positioned (above) to pick up where LTE Cat-4 (and Cat-6) leaves off, and eRedCap (not shown) is positioned to take over from Cat-1bis (and Cat-1). Ericsson, right, suggests RedCap completes a "unified 5G platform for all [IoT] use cases". (Source: Ericsson)

Cat-1bis) to make a fist of traditional IoT, at all – and it has a fight on its hands with well-entrenched non-cellular standards like LoRaWAN in unlicensed bands. But RedCap promises to fix that – somewhere down the line, as always with cellular.

RedCap is designed to make this familiar triangle of 5G NR family-tech into a venn diagram (see left, top), where it overlaps with the other three operating scenarios. This is actually Ericsson's diagram, taken from a full-blooded writeup about the latest NR release (#17). In terms of capabilities, it is supposed to plug a hole. Ericsson comments: "RedCap is positioned to address use cases that are today not best served using eMBB, URLLC, or LPWA (LTE-based mMTC) solutions."

RedCap is positioned "as a lower segment than eMBB… but higher than LPWA," it writes in a blog post. Huawei says the same (exactly, word-for-word, perhaps lifting from the same 3GPP messaging). Elsewhere, Qualcomm slots RedCap in between mission-critical IoT, served currently by consumer-like NR-based eMBB, but shortly by developing URLLC provisions, and massive-scale IoT, served by non-NR NB-IoT or LTE-M (or non-cellular LPWA tech like LoRaWAN), or more commonly by older category one-through-six (Cat-1, Cat-

> "The price gap between 4G and 5G modules is one of the essential factors – if not the most crucial factor – that will continue to limit 5G adoption in IoT… To reduce the price gap… there is a need to develop a 5G standard with fewer features and reduced hardware complexity. Without RedCap, 5G NR is missing a key technology piece for IoT."
>
> *Omdia*

1bis, Cat-4, Cat-6) versions of LTE (see left, bottom).

Analyst house Omdia calls RedCap the "big missing piece of the 5G IoT puzzle". Operationally, it is probably closest to LTE Cat-4 (see Qualcomm graphic above). Certainly, many of the use cases sound the same: the standard 3GPP line on RedCap is about industrial sensing, video surveil-

lance, and wearable technology, which might also be served by older categories of straight LTE. Omdia notes that challenge to make a business case for such use cases with 5G-priced hardware. It writes: "The price gap between 4G and 5G modules is one of the essential factors – if not the most crucial factor – that will continue to limit 5G adoption in IoT applications… To reduce the price gap… there is a need to develop a 5G standard with fewer features and reduced hardware complexity." RedCap is the answer, it says. "Without RedCap, 5G NR is missing a key technology piece for IoT."

Qualcomm talks, as well, about "applications in smart grids, environmental sensors, predictive maintenance, utility meters, high-resolution surveillance, and more". Which sound very LPWA-like, actually – and probably more NB-IoT and LoRaWAN, even, in lots of cases. It will take for a second generation of further-reduced RedCap units, specified in Release 18 as enhanced RedCap (eRedCap), to serve these markets. These will offering 5G alternatives to lower-range LTE-Cat-1 and single-antenna Cat-1bis hardware, and cheaper prices to boot. As written elsewhere in this report, ABI Research suggests eRedCap units will start to hit the market in proper volumes
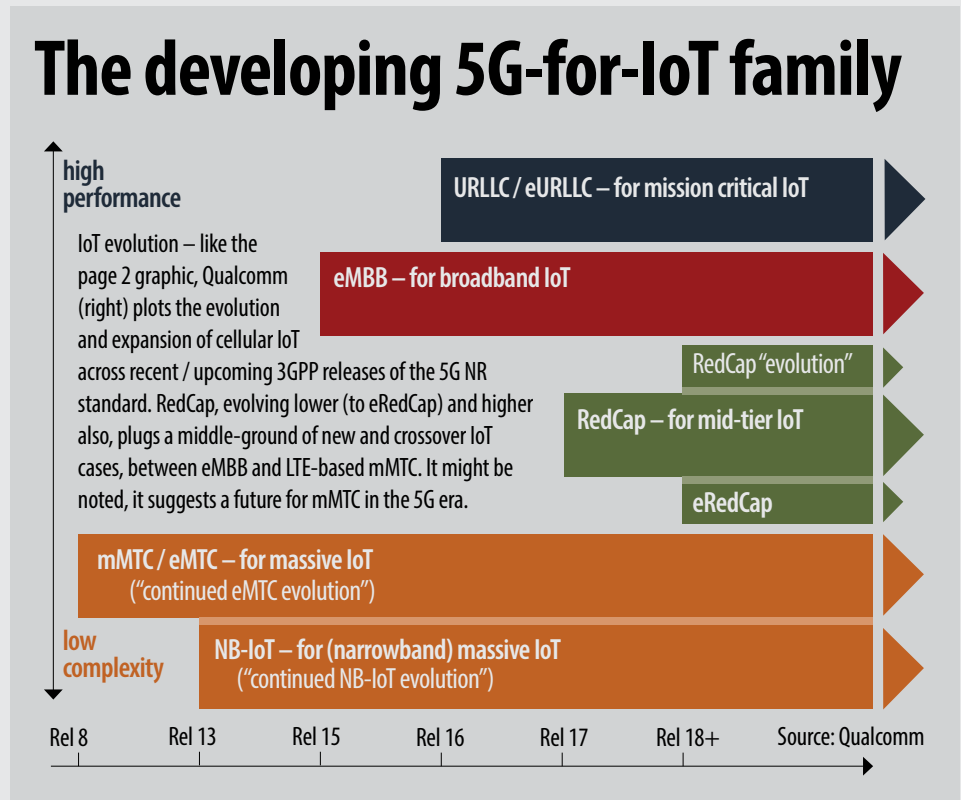
in 2026.

Ericsson is good on the technical achievement, around what has been jettisoned with first-generation mid-tier RedCap: bandwidth requirements, say, are reduced to 20 MHz and 100 MHz in frequency range 1 (FR1; 4.1 GHz to 7.125 GHz) and FR2 (24.25 GHz to 52.6 GHz); the number of 'receive branches' is reduced, also, meaning a reduction in receive antennas; the max number of downlink MIMO layers, equal to the number of receive branches, is also reduced.

There are other innovations, too, to make 5G viable for low-power IoT sensors apps, notably with more flex around modulation order, duplex operation / support. Ericsson writes: "Substantial cost and complexity reduction can be achieved… [to] establish RedCap as a distinct device segment from eMBB or [URLLC]." The upshot is lower device complexity, which results in lower cost, longer life, and enough grunt to get most IoT jobs done.

But the message about hole-filling might be considered a smokescreen; most of the industrial IoT applications linked with RedCap are variously quite-well served, from a technical point of view, by LPWA network solutions using NB-IoT, LTE-M, or LoRaWAN – or Sigfox or MIOTY (TS-UNB), or whatever else. And the 2024 time-frame (moving to 2025/26 for range and volume of deliveries) for Release 17 level RedCap-equipped IoT devices to appear gives the rest of the market room to manoeuvre, also.

And with key RedCap/eRedCap advancements – including higher transmission rates, advanced positioning, 'sidelink' near-field comms, and even support for unlicensed spectrum – only defined in Release 18, coming out in the second half of the decade, the IoT game for the cellular crowd remains a long haul. The big short-term (2024) boost is industrial enterprises, including those deploying private 5G, will be able to get two-for-one on IoT networks.

Omdia explains: "Enterprises looking to deploy a mix of… high-performance and mid-speed devices must deploy two [5G and 4G/LTE] separate networks… [which]

The developing 5G-for-IoT family

high performance

IoT evolution – like the page 2 graphic, Qualcomm (right) plots the evolution and expansion of cellular IoT across recent / upcoming 3GPP releases of the 5G NR standard. RedCap, evolving lower (to eRedCap) and higher also, plugs a middle-ground of new and crossover IoT cases, between eMBB and LTE-based mMTC. It might be noted, it suggests a future for mMTC in the 5G era.

URLLC / eURLLC – for mission critical IoT

eMBB – for broadband IoT

RedCap "evolution"

RedCap – for mid-tier IoT

eRedCap

mMTC / eMTC – for massive IoT
("continued eMTC evolution")

low complexity

NB-IoT – for (narrowband) massive IoT
("continued NB-IoT evolution")

Rel 8   Rel 13   Rel 15   Rel 16   Rel 17   Rel 18+   Source: Qualcomm

"Enterprises looking to deploy a mix of… high-performance and mid-speed devices must deploy two [4G/5G] networks… [which] creates extra cost and complexity… Since most operators do not have immediate plans to phase out 4G networks, this issue is not a primary concern. However, this issue will become a more critical factor in a few years."

Omdia

creates extra cost and complexity. There is no upgrade path for existing… [LTE-M] devices to migrate to 5G NR. Since most operators do not have immediate plans to phase out 4G networks, this issue is not a primary concern. However, this issue will become a more critical factor in a few years."

So really the motivation with RedCap, as Omdia indicates above, is to migrate new and legacy M2M/IoT contracts to 5G NR in time for sun-setting LTE and, with it, NB-IoT and LTE-M, and everything else. Qualcomm states: "As the 5G evolution continues, there will come a time in the future when communications service providers start to migrate away from 4G toward 5G. With this in mind, [RedCap] becomes the platform of choice for future-proofing new mid-tier IoT designs."

Or does it? It still sounds like a long way off – like another future cellular tech without an ecosystem, or an easy way to sell, and a track record that does not bring clear optimism. ●

ons RedCap can reduce 5G module costs by as much as 80 percent compared to their full-fat 5G equivalents, and lower power consumption by over 30 percent; plus end-users get support for NR-native benefits like higher capacity and reliability (both by a "factor of 10", says Huawei), plus new slicing and positioning.

Fang says: "In many application scenarios, such as smart factories, smart security, and smart wearables, RedCap uses lightweight modules to reduce the cost and complexity of 5G terminals, popularise 5G IoT applications, and enable ubiquitous 5G IoT. At the same time, operators can fully reuse existing 5G infrastructure, including sites, baseband units, radio frequency units, and antennas. Through software upgrades, operators can quickly deploy RedCap, driving connection growth, traffic growth, and service growth, achieving small investment and large profits." Indeed, much of the attraction, including financial, is how RedCap slots into the existing 5G NR system.

But this 80-percent figure is a theoretical statement, actually; new technologies come with a premium, and the Industry 4.0 market, especially when it comes to massive-scale IoT sensor deployments, is cost-sensitive. It also turns on long upgrade cycles, and is no rush to invest prematurely on expensive kit. It is a false comparison, as well, because 5G modules are way too expensive for industrial IoT, presently; an 80 percent reduction on way-too-much is still too-much for lower-end IoT solutions. Which is why premium cases like surveillance cameras and consumer wearables are being targeted out-of-the-gate.

Patsioura at GSMA Intelligence says: "More devices are needed in the market… Cheaper sensors are needed… But where data rates and performance are key attributes, then cost becomes less of a priority, and RedCap can drive higher IoT adoption." But more generally, 5G RedCap will usurp

80%
up to reduction in module costs with RedCap, versus standard 5G
– Huawei
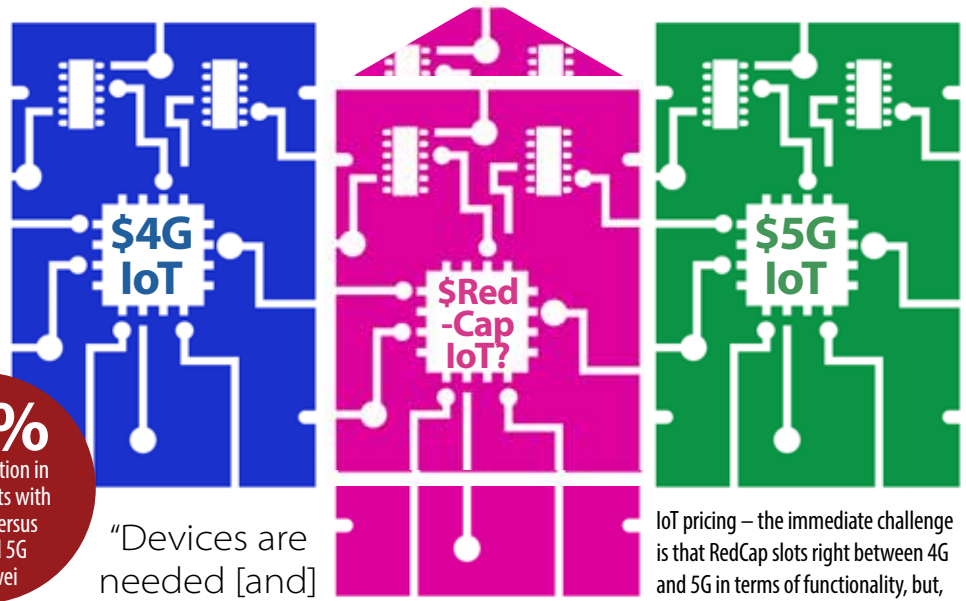
"Devices are needed [and] Cheaper sensors are needed… But where data rates and performance are key attributes, then cost becomes less of a priority, and RedCap can drive higher IoT adoption."

Christina Patsioura,
Lead Analyst,
IoT and Enterprise,
GSMA Intelligence

IoT pricing – the immediate challenge is that RedCap slots right between 4G and 5G in terms of functionality, but, as new tech, comes with an almost 5G-like price premium, and must ultimately hit 4G-like prices to succeed in IoT.

x3
the premium on current RedCap modules, versus standard 4G/LTE units
– ABI Research

LTE/4G only when IoT module prices halve, after 2027, reckons ABI Research. Despite "keen interest" from IoT manufacturers, high prices will hold RedCap back in the short-to-medium term, it reckons. RedCap modules are currently going for about three times the price of their LTE-based Cat-4 equivalents, which they will displace, nominally, in terms of performance features for IoT use cases.

ABI Research says it will take until 2027, when current RedCap hardware prices fall by 50 percent, and also until the arrival of further-reduced eRedCap modules at a lower price-point in 2026, for the sales to jump. The latter will enter the market at a more manageable 25 percent premium versus current LTE Cat-1 modules, which they rub up against – and compared with the 300 percent premium for RedCap modules currently, versus Cat-4 units. "Most IoT OEMs will not pay [much more] for a technology they do not yet need. IoT revenues will likely remain limited in the short term due to excessive module pricing," says Budd.

In 2024, 5G RedCap modules are expected to sell at around the $50 mark, equating in some cases to a three-fold price premium

Video surveillance and fixed-wireless access devices to lead RedCap growth

The IoT market for reduced capability (RedCap) 5G modules will be driven initially by applications for remote monitoring and control, video surveillance and security, and fixed wireless terminals.

Sales of these will contribute around 50 million shipments between 2024 and 2029, equivalent to 58 percent of the total RedCap shipments in the period, reckons ABI Research. It puts the total RedCap IoT module market at about 86.2 million units over the period.

The IoT sector is to pile in on 5G-based RedCap shortly; as it stands, interest in RedCap is mostly for mobile broadband and fixed wireless access (FWA) applications. But RedCap is positioned as a stripped-down and cheaper alternative to regular 5G, with more traditional 4G-LTE capabilities, and holds notable appeal in the IoT market.

ABI calls it a "natural replacement for the LTE categories on which… mid-range IoT devices frequently rely". As a frame of reference, RedCap offers comparable throughput performance to LTE Cat-4 and LTE Cat-6; enhanced RedCap (eRedCap) delivers equivalent throughput performance to LTE Cat-1 and Cat-1bis. Most RedCap IoT devices can be categorised in two areas, says ABI Research: as FWA terminals, including routers and gateways, for business-critical connectivity fallback in industrial and retail settings; and as IP cameras for video surveillance.

There is also strong interest in RedCap from automotive manufacturers in China and Europe to connect entry-level vehicles, it says. In the longer term, eRedCap offers a greater market opportunity in terms of IoT unit shipments, says ABI Research.

The first RedCap chipsets, arriving "by 2026", should drive "another wave of migration from devices with a strong affinity to LTE Cat-1". These will include point-of-sale (POS) and telehealth devices, also.

Jonathan Budd, industry analyst at ABI Research, said: "5G RedCap is drawing interest across the IoT value chain, with video surveillance and FWA terminals dominating the first device launches in 2024. Devices with lifecycles upwards of eight years are more likely to migrate to RedCap in the near term. Doing so allows manufacturers to future-proof their devices, offsetting some uncertainty surrounding 4G network longevity."

China and North America will move aggressively on RedCap and are expected to account for approximately 80 percent of RedCap shipments in 2029, the company reckons. Budd says: "With accelerated [standalone] 5G (5G SA) rollouts and the expectation of more imminent phasing out of LTE networks, China and the US are likely to lead the early RedCap module shipments for IoT markets." ●

"RedCap is drawing interest across the IoT value chain... Devices with lifecycles upwards of eight years are more likely to migrate... in the near term. Doing so allows manufacturers to future-proof their devices, offsetting uncertainty around 4G."

Jonathan Budd,
Industry Analyst,
ABI Research

FWA devices – versions of (non-RedCap) 4G and 5G fixed-wireless access (FWA) devices above, from Cisco, will be quick to adopt RedCap. (Image: Cisco)

on LTE Cat-4 modules. Without the immediate threat of LTE network shutdowns, device OEMs are unlikely to upgrade, except for devices with longer lifecycles. Most IoT OEMs will not pay for a technology they do not yet need; as a replacement technology for LTE, 5G RedCap module ASPs must be driven down by at least 50 percent to make RedCap economically viable for manufacturers."

He suggests eRedCap modules – "mostly going into security, telehealth, point-of-sale, and remote monitoring devices" – will be priced at between $10 and $15 per unit on arrival. "With more widespread 5G SA coverage expected by this time, eRedCap migration is projected to take off more immediately than 5G RedCap. 5G RedCap revenues are only expected to surge following the release of optimised second-generation chipsets in 2026. Coupled with greater manufacturing volumes, we should see 5G RedCap module ASPs halving by 2027, driving an additional wave of migration from LTE," he says.

The only way the price of RedCap devices decreases, realistically, is if production of them increases. Which depends on 5G SA infrastructure in the first instance, and RedCap support in the second – as discussed. Which depends, to an extent, on the longevity of LTE-based IoT devices and LTE-based IoT networks. Budd says: "RedCap (and eRedCap) is seen primarily as a replacement technology for Cat-4 and Cat-1, meaning there are few additional features that really incentivise device OEMs to migrate – apart from securing their devices into the 5G era. So the sooner we expect LTE shutdowns the sooner we can expect OEMs to consider RedCap as part of their roadmaps."

Which, again, is why stripped-back eRedCap holds greater promise in the medium term; but even then, Cat-1 positioned eRedCap will likely come in at Cat-4 equivalent prices. "Without the immediate concern of LTE network shutdowns, device OEMs are not essentially going to pay for a technology they don't yet need – unless it is to future-proof their devices. And it is expected that the first 5G RedCap modules will be sold at a significant premium to LTE Cat-4.

Four early apps for eRedCap

25%
premium for eRedCap modules, versus 4G/LTE, when they hit market – ABI Research

'TELEHEALTH'

SURVEILLANCE / CAMERAS

POINT-OF-SALE(RETAIL)

REMOTE MONITORING (HEALTH)

Images: 123rf

So it may be that we have to wait for cheaper optimised second generation chip sets to drive prices closer to LTE Cat-4," says Budd. Of course, IoT makers have their own lifecycle agendas, as well.

He adds: "If we think of a device segment with a lifespan of 10 to 20 years, such as water meters, then LTE networks may be phased out before they actually need to be replaced. So [meter] OEMs, for example, are perhaps more likely to pay the premium on RedCap modules to ensure their devices [work on] 5G [SA]." Patsioura at GSMA Intelligence says the same: "In cases where longer life is mandated, such as cameras for public sector projects, and other smart city applications, then RedCap would win [versus] LTE-based counterparts. So we see different adoption scenarios – with some open questions still to be answered over the next few years."

Which says it all, perhaps – "key questions" are still to be answered, about switch-offs and switch-ons, and use cases and business cases. "2025 will be a key year, with activation of RedCap in the US, and key RedCap product and module launches, probably around CES and MWC. Then we will know better where things are actually headed," says Patsioura. In the meantime, it is a lot of educated guesswork. For 1NCE, which piggybacks on carrier infrastructure around the world, providing 23,000 customers with global IoT airtime and services, the jury remains out. For now, RedCap is another premature 5G/IoT hype story, says Sulaiman.

"We saw what happened with NB-IoT and LTE-M – which, even now, eight or nine years after they launched, do not offer global coverage. So RedCap is going to take time," he says, at the same time as suggesting RedCap might make its mark in the short term as a point solution for industrial private 5G SA networks – notably in territories that do not permit private spectrum for LTE/4G based usage. Sulaiman says: "Down the road… RedCap will start to find its mark in private networks, more in

the mid-tier IoT space… But it will still take some time." This is picked up, separately, in conversations with integrators and enterprises about private 5G networks. But this is not the forum, and private 5G, developing a steady Industry 4.0 fanbase, faces its own challenges to crack the industrial mass-market.

Meanwhile, global RedCap-based IoT on public 5G SA networks looks like a longshot, says Sulaiman on the webinar. "It will not impact the market for quite a few years. There is going to be an imbalance between what enterprises expect and how fast operators move on it – to make it a global service. Which is what [cellular] IoT is all about, right? It is a global service; there are not [national or even regional] use cases… RedCap will remain a specialised tool for two or three years. It's not going to be a mass market IoT disruptor. Because wide coverage, long life, low costs are critical for scaled IoT. And these are not being addressed by RedCap, currently."

He aims a couple of digs at the operator community for their big talk and poor record with new tech – by way of a response to a question about whether RedCap is over-hyped (plus some deft 1NCE hype). "It is hard to predict a decade ahead. But it feels like something that is being driven by operators…. Operators invent a lot of things, which only actually work when software companies… make businesses out of them. [RedCap is] one of these cases; it was invented by operators [without much attention] to the companies and people who need it. [Time will tell if it works but] unfortunately history tells us that it doesn't always. So for the moment, I would consider it more of a hype topic, yes."

Closing the webinar session, Patsioura responds: "I do not necessarily agree. I would just go back to who sets expectations. I'm not sure operators are so hyped-up about it either to be honest – about implementing it right now. But we also know RedCap is a better technology. We know it has technical improvements, and it's 5G-native."

She also talks about invariable overlaps of new and old network technologies, sug-

"We saw what happened with NB-IoT and LTE-M – which, even now, eight or nine years after they launched, do not offer global coverage. So RedCap is going to take time. Down the road… it will start to find its mark in private networks [and] more in the mid-tier IoT space… But it will still take some time"

Jan Sulaiman
Vice President,
Global IoT Solutions
1NCE

gesting even 2G is "a growth business for many, many companies". Which muddies the waters, a little. But her point, again, is that RedCap will work with a price premium for certain high-value or long-life applications, and migrate down the IoT value chain over time, as production ramps and prices

fall. Ultimately, it will enable brand new use cases, as well, she says.

"I wouldn't call it niche, although it is niche at the moment. I would call it very-early stages… Yes it is taking longer [than expected] but there are reasons for that. One is [these] SA rollouts. But there are other reasons as well… The IoT ecosystem, broadly targeted, wants to make sure [of new technology]. It has other (different) priorities. But other parts of the market have started preparing for it now. The first modules are in the market; early use cases have started… RedCap is a great segue to higher-value IoT use cases. It's just going to take time… It is always the business environment, right? Financing, uncertainty, sentiment, things like that."

But the last word goes to Budd at ABI Research, to comment on another analyst's grand-standing about RedCap as the "missing piece in the 5G-IoT puzzle"; he pauses and responds: "There are a few ways to cut this. If we're looking into that gap between 5G service areas, between mMTC and eMBB, then I suppose RedCap does plug in there for those devices that are currently served by Cat-1 to Cat-6… And so if RedCap is the natural successor to those technologies, it will be extremely valuable to drive 5G connections. On the other hand, I suppose RedCap is really there essentially to prevent LTE from becoming the next 2G – in that it persists so long that it actually impedes 5G adoption, and prevents operators from reframing spectrum."

He closes: "In that sense, I would say there is a fair amount riding on it. It goes back to the behaviour of the OEMs, as well, which is the interesting part of this – about how protracted that migration will actually be. Will OEMs leave it to the very last minute to migrate if we don't see a drastic swing downwards, towards parity with LTE-based module pricing – which may veer into the 2030s. These are all things we need to consider. I suppose just in terms of plugging that gap it might be considered the missing piece but in practice it is very much a case of when the implementers decide to consider this as part of their roadmaps." ●

Expanding 5G to new use cases– talking RedCap with Qualcomm

Qualcomm, a key mover in cellular IoT, puts the case for RedCap – for expanding, securing, and simplifying its global usage

Reduced-capability 5G (RedCap) technology, part of the so-called Release 17/18-level '5G Advanced' feature set, is key to the evolution of 5G, reckons US chipmaker Qualcomm Technologies. It is positioned to bridge a gap for IoT and non-IoT use cases that do not require full-fat 5G capabilities. "RedCap is optimised for efficiency, scalability and simplicity," explains Gautam Sheoran, vice president and general manager for wireless broadband at Qualcomm. All of which – reduced capability – means lower costs for 5G-based hardware.

Sheoran says: "It uses less power and affords a smaller footprint, but provides access to global 5G infrastructure and sufficient performance for the use cases it is designed for. It provides all the benefits of 5G but with an entry-level broadband data rate of around 220Mbps. And that focus on entry-level broadband means we can expand 5G to new use cases – anything from massive IoT deployments, to extended reality (XR) and wearables, and entry-tier broadband devices." It works for connected PCs and a wide range of other 5G device classes, as well, he suggests.

In the end, its promise of lower-cost hardware endears it, potentially, to large-scale IoT deployments. Sheoran cites multiple industries that might make use of RedCap at scale – which want 5G, just not all of it, and just at standard 5G prices. Examples are pretty well understood: remote monitoring

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>
> **Gautam Sheoran,**
> **Vice President and General Manager, Wireless Broadband, Qualcomm**

and diagnostic tools in the healthcare sector; fleet management and vehicle diagnostics in the automotive industry; entry-level gateways and wearable devices like smartwatches and fitness trackers in the consumer space. So says Qualcomm.

Because not everything is about "ultra-low latency transmissions", of course; sometimes all an enterprise application requires is "reliable and efficient connectivity", says Sheoran. Which is very plain; it is the same reason NB-IoT and LTE-M were created, separate from full-fat LTE; and the same reason old versions of LTE (Cat-1, Cat 1-bis, Cat-4, commonly) have been adopted by the IoT community to serve different use cases. Other industries that can benefit from the right-sized 5G devices are… well, all of

them: logistics, agriculture, manufacturing, cities, and so on.

5G RedCap has a home anywhere mid-range IoT is required, implies Sheoran. "RedCap exists because the industry needs a solution for connectivity that is appropriate for use cases beyond smartphones." Qualcomm introduced the Snapdragon X35 RedCap modem ('RF System') in 2023. Awareness is "rapidly increasing", says Sheoran. "Since RedCap changes the story about what's possible in smart devices, evangelism and new narratives will encourage industry partners and innovators to conceptualise products and market spaces that have not been explored to date."

Or so everyone hopes; so the beat of the telecoms drum always goes. He adds, revealing his hand to an extent: "Equipment makers and mobile operators stand to benefit greatly from the growth of RedCap and should be considered pivotal communication partners in the growth of this technology." For developers, the great opportunity with RedCap is to get 5G into new markets, as well as to offer an upgrade path for LTE-based units. But there are challenges, as always. "Designing connectivity in any device is highly complex," says Sheoran.

He goes on: "Challenges with RedCap may include power management, efficient antenna designs, thermal management, as well as software, firmware and security. "To fully take advantage of RedCap hardware, the software must support it. It can take time and new expertise to create this code, as well as the support for RedCap's security features. Having a secure update process for a RedCap product is important, but it can be challenging to create for unattended devices like sensors and industrial devices." But decisions about these aspects create opportunities, too.

Sheoran says: "RedCap modems are built so they can be incorporated into devices with limited power budgets and thermal envelopes. The reduced data rate changes the modem architecture. Thermal and power [are reduced]. It means developing products is more cost-efficient." Indeed, support for fewer antennas and frequency bands

Images: 123rf

"Fragmentation limits the ability to scale… and complicates the integration of components… These challenges are amplified by the cost… RedCap [will] drive consolidation – resulting in less training, more compatibility, better security, better future-proofing."

Gautam Sheoran,
Vice President and General Manager, Wireless Broadband, Qualcomm

means smaller and cheaper devices – eventually, in theory – which is a major selling point for its adoption in smaller IoT devices like sensors or wearables." Until hardware prices reduce (drastically), it won't usurp NB-IoT for bare-bones cases.

But the scope is there, at the same time, suggests Sheoran. "RedCap supports massive machine-type comms (mMTC), this

collection of technologies designed for IoT cases with large numbers of devices sending small, periodic data packets. It provides simplified network slicing and efficient device management for large-scale deployments, which is essential for IoT growth." It also keeps certain inherent goodness from its parent 5G tech; its security features are a good example, he says, pointing to its enhanced data encryption and authentication protocols.

"It's important for integrators to leverage these security capabilities to protect devices and networks using 5G RedCap," he says. At the same time, stripped-back IoT devices in massive numbers invariably present a big attack surface to hackers, and so enhanced security protocols should be observed. "RedCap is designed to inhabit devices that may not have the power budget for complex security software, and in which unauthorised physical access, including supply chain attacks, may not be readily obvious. Insecure APIs also represent a threat," says Sheoran.

And what about pitching a new cellular technology into an IoT connectivity market that is already confusing? Sheoran goes so far as to suggest RedCap can rule them all, and solve this issue with market fragmentation. "It holds significant promise for unifying fragments in the IoT landscape. For example, by extending 5G to low-cost, low-power IoT, it helps integrate and streamline various existing solutions in the connectivity space, such as low-power LTE (LTE-M), narrowband IoT (NB-IoT), and traditional 5G."

He adds: "Technology fragmentation often limits the ability to scale installations and complicates the integration of existing components with newer ones. These and other challenges are amplified by the cost of managing a fragmented IoT installation: related to the need for different, sometimes incompatible, software management solutions and training. RedCap [will] drive consolidation of IoT connectivity technologies – resulting in less training, more cross-device compatibility, more security visibility, better future-proofing." ●

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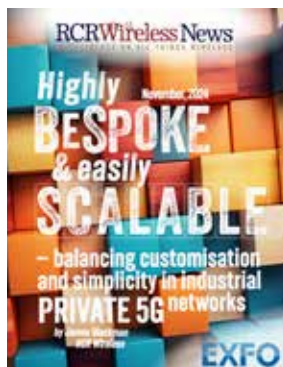
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