DEVELOPER NATION

# THE STATE OF CLOUD NATIVE DEVELOPMENT

The latest trends from our Q3 2021 survey of 19,000+ developers

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CLOUD NATIVE COMPUTING FOUNDATION

MAY 2022

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We survey 30,000+ developers annually – across web, mobile, IoT, cloud, Machine Learning, AR/VR, games and desktop – to help companies understand who developers are, what they buy and where they are going next.

## WHO DEVELOPERS ARE

Developer population sizing
Developer segmentation

## WHAT THEY BUY

Why developers are adopting competitor products – and how you can fix that

## WHERE THEY ARE GOING

Emerging platforms – augmented & virtual reality, machine learning

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# KEY INSIGHTS

- The global number of cloud native developers has grown by 1M in the last twelve months to 7.1M in Q3 2021. →
- Overall, cloud native computing is now most widely adopted in North America (48%), South America (47%), and Oceania (50%). →
- Cloud native developers are leveraging multiple deployment environments: 54% of cloud native developers use two or more environments to run their code, while only 40% of non-cloud native backend developers do. →
- As of Q3 2021, 30% of developers have used Kubernetes in the last 12 months — an estimated 5.1M backend developers. →
- The most cited reason why backend developers don't use Kubernetes — given by 36% of those developers — remains a lack of applicability or interest. →
- The larger an organisation a backend developer works for, the more proportionally likely they are to be using Kubernetes. →
- The top three vendors offering managed orchestration services — Amazon, Google, and Microsoft — dominate the market. →
- The way in which developers engage with serverless products is changing. With developers choosing fewer serverless products to use simultaneously, competition among vendors in this landscape is set to become fiercer. →
- Among cloud native developers, those who are more security-focussed are more likely to be able to affect tooling purchasing decisions. →

# Introduction

# A. Roadmap

The way software is developed has drastically changed since containers came about and cloud native technology gained popularity. Commissioned by Cloud Native Computing Foundation (CNCF), SlashData has performed an in-depth analysis of the cloud native developer ecosystem[1] to better understand its current state and expected evolution.

The analysis is based on the 21st edition of SlashData's Developer Nation survey, which was fielded between June 2021 and August 2021 and reached more than 19,300+ developers globally[2]. 3,900+ survey participants answered questions relating to the development of backend services and the technologies they use.

The first chapter of this report provides estimates for the global number of cloud native developers and an in-depth regional overview of usage rates. Further, we deep-dive into the environments developers are leveraging to deploy the code of their backend services and we contrast cloud native with non-cloud native developer usage.

Kubernetes is arguably at the heart of cloud native applications and in the second chapter, we examine developers' usage and awareness of Kubernetes in an attempt to identify the drivers that facilitate its adoption across different developer profiles and technologies. We profile Kubernetes users in terms of professional status and the size of the organisation these developers work.

Chapter three gives an in-depth overview of various vendors' container orchestration and serverless platform solutions and examines how the market share of these tools has changed over the last six months.

The report concludes by exploring security in the cloud native space. Here, we focus on whether security is a modern priority, specifically looking at the level of influence that security-concerned cloud native developers have on tooling purchasing decisions.

*[1] Cloud native developers are defined in the next section.*
*[2] See the Methodology chapter for more information about how the survey was conducted.*

# B. Defining cloud native computing

As in our previous report[3], we use CNCF's definition of cloud native computing as a guide for this analysis:

*"Cloud native technologies empower organisations to build and run scalable applications in modern, dynamic environments such as public, private, and hybrid clouds. Containers, service meshes, microservices, immutable infrastructure, and declarative APIs exemplify this approach. These techniques enable loosely coupled systems that are resilient, manageable, and observable. Combined with robust automation, they allow engineers to make high impact changes frequently and predictably with minimal toil."*

This report focusses on developers who self-identify as working in the backend services sector. These are developers who are writing server-side code. The servers could be housed on-premise or in a third party's data centre. Segmenting further, we focus on cloud native developers. In order to identify these developers, we examine what technologies they are using to build backend services. Containers are the most popular technology: three in five backend developers use containers. We do not, however, class them all as cloud native developers. While the use of containers may be an important first step in moving to cloud native development, without automation, it remains exactly that: only the first step.

Returning to the CNCF definition, note that the key is the use of automation to make high impact changes frequently and predictably with minimal work. As CNCF was initially developed around Kubernetes and container orchestration, we consider these to be at the core of cloud native computing. Consequently, we have limited the definition of cloud native developers to those that are using some sort of container orchestration solution or serverless platform.

[3] *The State of Cloud Native Development Q1 2021*

# 1. The Cloud Native Landscape

# A. Market size

Our estimates put **the global number of cloud native developers for Q3 2021 at 7.1M**, or 41% of backend developers. The population includes 4.8M backend developers using container orchestration tools and 4.2M backend developers using serverless platforms, as well as a 1.9M overlap of developers using both orchestration and serverless technologies.

To provide context, we only show the population trend of those using containers, although not all of those developers are considered cloud native developers[4]. In Q3 2021, we estimate the global population of developers using containers is 10.4M, or 60% of backend developers. This is the most ubiquitous technology in backend services development.

Usage of all cloud native native technologies shows an upward population growth. This has been driven by a robust increase in the total number of backend developers, from 15.1M in Q3 2020 to 17.3M in Q3 2021.

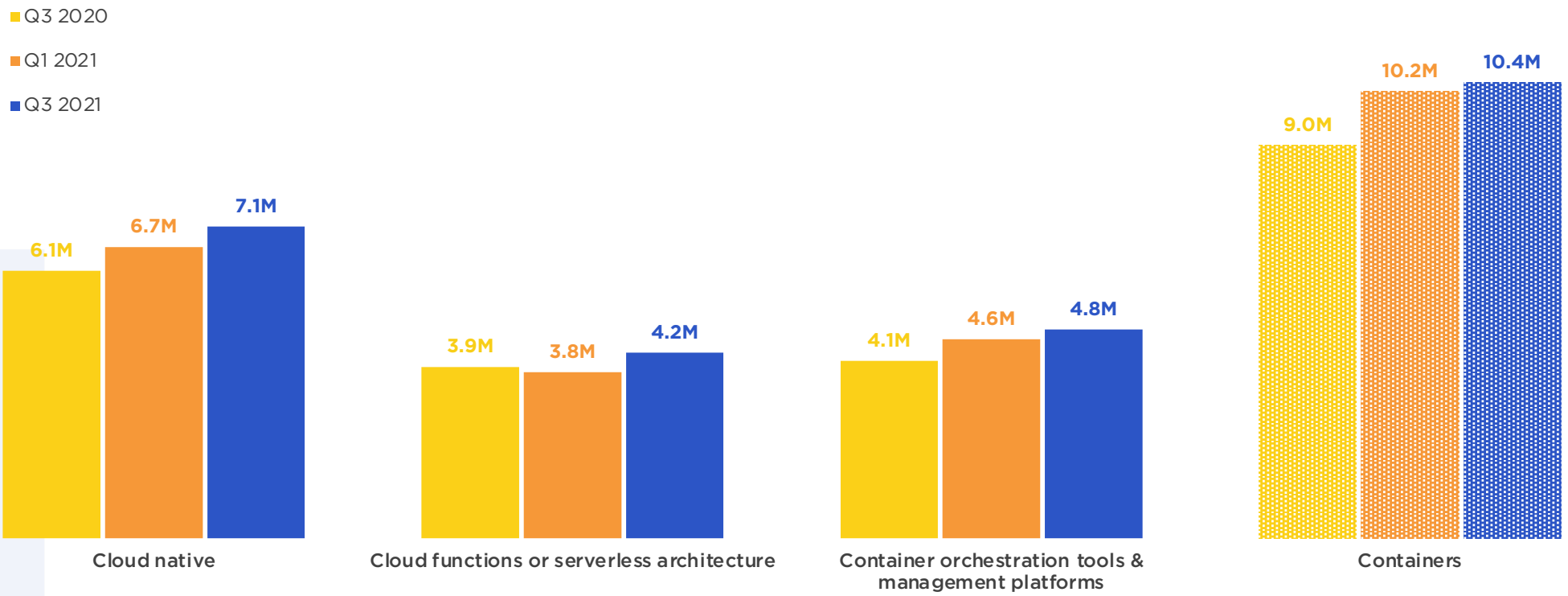
For the cloud native developer population specifically, **the population has grown by 1M in the last 12 months**. However, as a proportion of the backend developer population, the cloud native developer community has remained stable — between 40% and 41% of the backend population.

*[4] See the previous section for a definition of cloud native developers.*

# The cloud native developer ecosystem has added 1M in the past 12 months

Number of backend developers (in millions) (Q3 2020 n=3,978 | Q1 2021 n=3,600 | Q3 2021 n=3,941)

## Growth of the backend developer population



# B. Regional usage of cloud native technologies

The usage of containers and cloud native technologies varies significantly by region. Barring Eastern Europe and the Greater China area — two regions which we will discuss shortly — the proportion of **backend developers who use containers and container orchestration tools has remained relatively unchanged in the past year** — between Q3 2020 and Q3 2021. The **adoption of serverless solutions has shown more variability** — increasing in North America, South America, and Oceania and decreasing in Western Europe, East Asia, and the Greater China area within the last 12 months.

Overall, cloud native computing is now most widely adopted in North America (48%), South America (47%), and Oceania (50%).

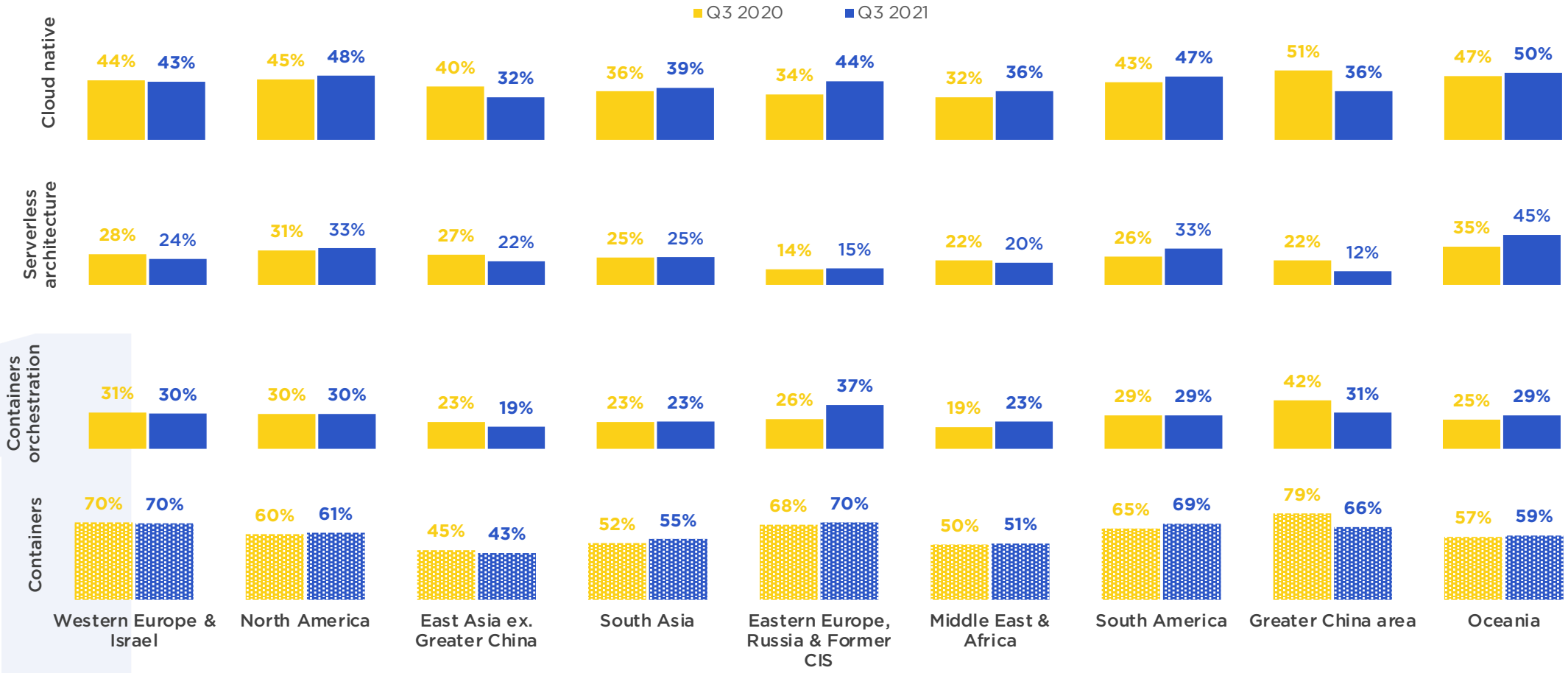
With **44% of backend developers classed as cloud native, Eastern Europe is the fourth region where cloud native computing is most widely adopted**. The region has shown a significant increase of 10 percentage points in the cloud native developer population within the last 12 months. It is also the region which has had the most significant redress in terms of gender dynamics: in Q3 2020, 95% of cloud native developers in Eastern Europe were male; the highest proportion of males in any region. By Q3 2021, this has decreased to 91% — almost on par with the global cloud native population which is 90% male, 8% female, and 2% gender fluid/multiple genders/non-binary, agender/none, or preferred not to specify.

**East Asia and the Greater China area show severe decline in usage of cloud native technologies.** In Q3 2020, four in ten backend developers in East Asia were cloud native developers. 12 months later, the cloud native developer population has dropped by 8 percentage points, to 32%. Usage of all cloud native technologies have simultaneously fallen. A recent CNCF report, showed that developers in China thought complexity, security, and reliability were the top challenges with using containers.

# East Asia shows decline in usage of cloud native technologies

% of backend developers in each region (Q3 2020 n=3,978 | Q3 2021 n=3,941)

## Usage of cloud native technologies across regions



# C. Where cloud native developers are running their code

In our survey, we asked backend developers where their code runs, with potential answers including on a public cloud, private cloud, hybrid cloud, multi-cloud, and on-premise servers. These options are not mutually exclusive. For greater clarity, within the survey, we define a private cloud as a cloud that is only available to certain users regardless of whether it is hosted on-premise or in a third party's data centre. We also define hybrid clouds as using a combination of public and private clouds for a single project and multi-clouds as using multiple public clouds for a single project.

**Cloud native developers are leveraging multiple deployment environments.** 54% of cloud native developers use two or more environments to run their code, while only 40% of non-cloud native backend developers do. The flexibility of cloud native development enables organisations to operate with distributed environments and allocate workloads to compute resources best suited for any particular job.

Analysing which environments cloud native developers are using in order to take advantage of this flexibility yields **public cloud, on-premise servers, and private cloud as the three most popular environments** — all used by more than two in five cloud native developers.

Comparing cloud native developers to their non-cloud native peers, **cloud native developers are more likely than other backend developers to use cloud environments**, illustrating how cloud native development is all about leveraging the capabilities of the cloud. On-premise servers, together with mainframe, are the only two environments where non-cloud native developer use exceeds cloud native developer use.

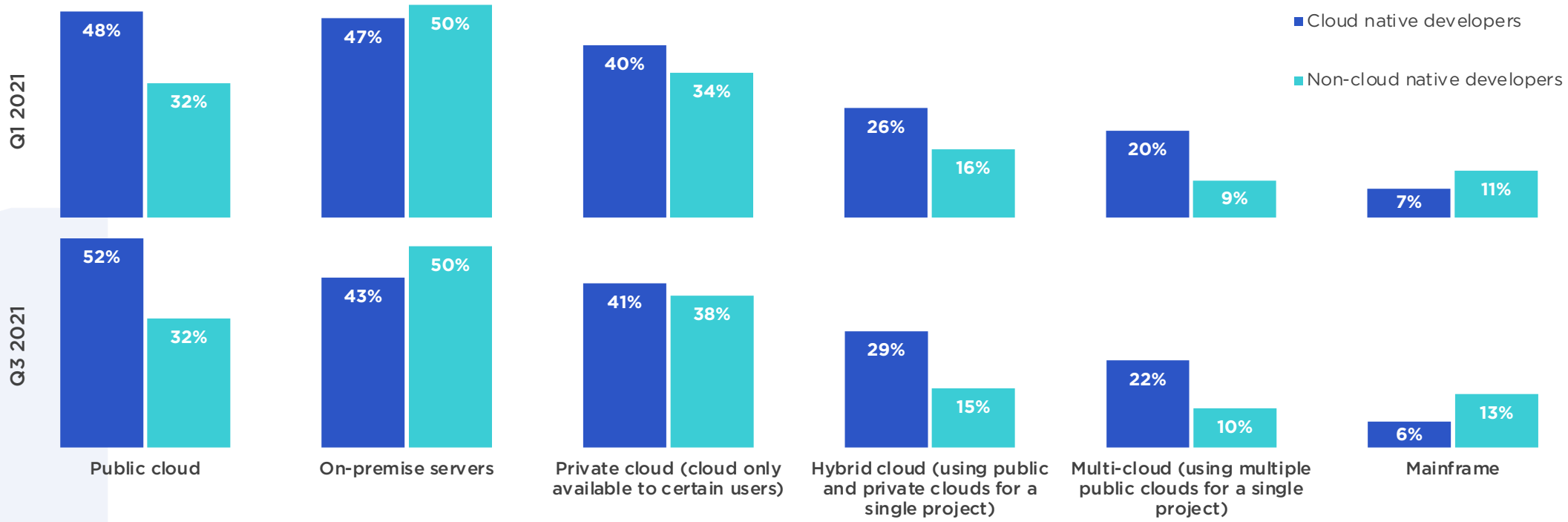
Over the last six months — from Q1 2021 to Q3 2021 — usage of almost all environments among cloud native developers has decreased slightly. On-premise servers are the exception: usage rose 4 percentage points in this period. Cloud native developers seem unwilling to abandon existing on-premise servers — often using this environment in addition to cloud environments. This behaviour could possibly be due to company policies requesting that developers run their code on on-premise servers to maintain a certain level of security and control over the data. As we'll see in chapter four, security-focussed cloud native developers are more likely than those who aren't security-focussed to be company decision makers.

*Note: In Appendix B, we deep-dive to examine where cloud developers involved in telecommunications run their code.*

# Cloud native developers rely more heavily on cloud environments than their non-cloud native peers

% of backend developers who use each environment (Q1 2021 n=1,798 | Q3 2021 n=2,039)

## Where backend developers run their code



# 2. Usage and Awareness of Kubernetes

# A. Kubernetes usage and awareness among backend developers

We asked more than 5,500 backend developers about their awareness and usage of both Kubernetes and containers. This large sample comprises both cloud native and non-cloud native developers and provides a clear picture of how well-known these cloud native technologies are among the whole population of backend developers.

This section explores backend developers' awareness and usage of Kubernetes and containers. As of Q3 2021, 61% of backend developers had used containers in the last 12 months and 30% of developers used Kubernetes to orchestrate these: an estimated 5.1M backend developers. The overall usage of Kubernetes is reasonably stable — increasing slightly by 2 percentage points between Q3 2020 and Q3 2021.

Although the percentage of developers using Kubernetes has remained relatively stable, many backend developers remain unsure of what it can do for them. One in ten developers have never heard of Kubernetes, and roughly one in four are unsure what it does. However, **the most cited reason why backend developers don't use Kubernetes — given by 36% of these developers — remains lack of applicability or interest**. Therefore, it may be that most backend services are still simple enough to require container orchestration or that some of those developers rely on Container as as Service (CaaS) solutions without knowledge of or interest in the orchestration engines that power these.

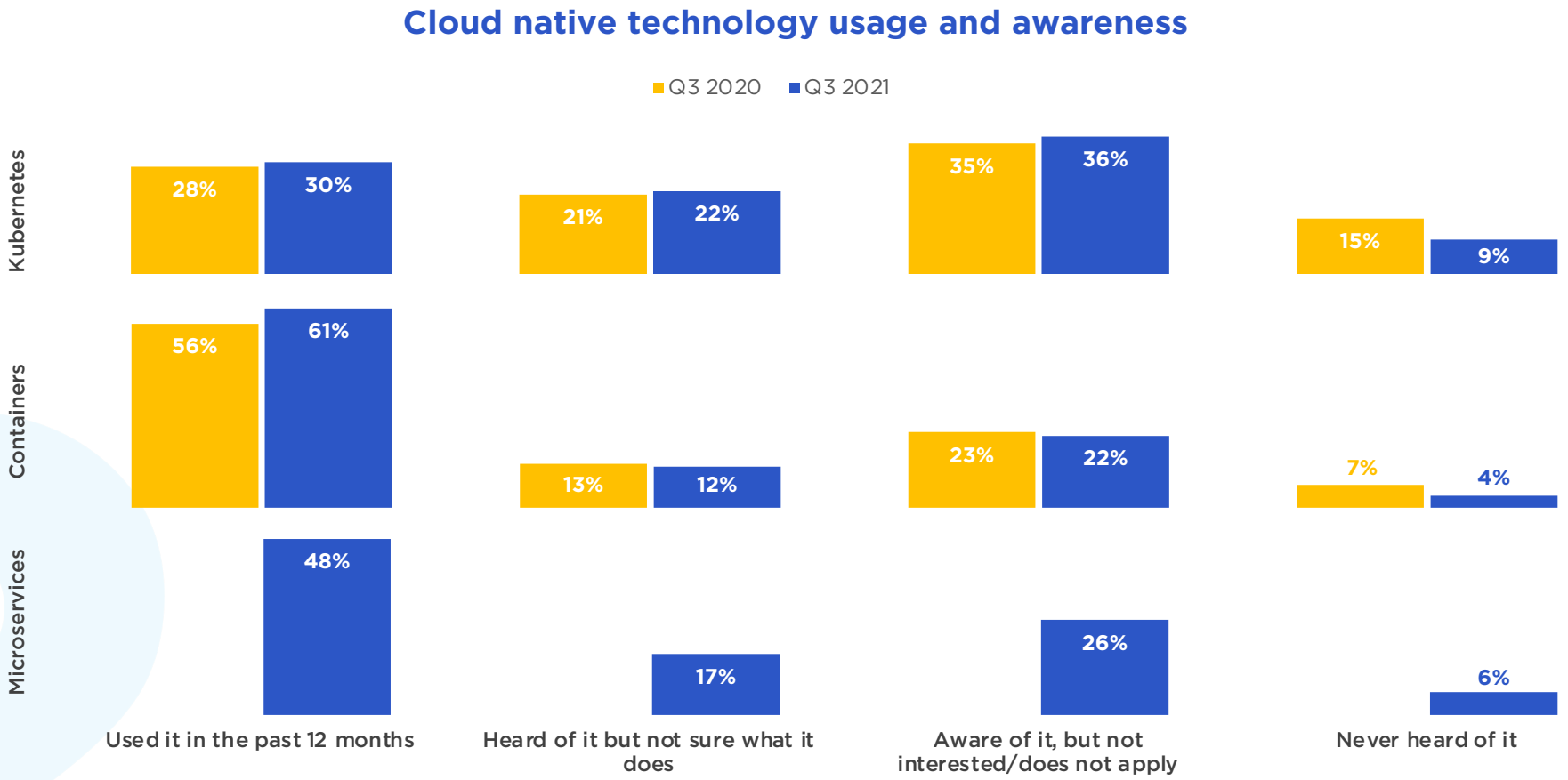
In the rest of this chapter, we deep-dive into the profile of developers who have endorsed Kubernetes — in the process, understanding who hasn't adopted this technology.

One thing is already clear: Kubernetes appeals particularly to backend developers who are already interested in or heading towards cloud native computing. **Among cloud native developers, 47% use Kubernetes** and only 3% have never heard of this technology.

In Q3 2021, we also began tracking usage and awareness of another cloud native technology, microservices. 48% of backend developers have used microservices in the last 12 months. This increases to 66% among cloud native developers.

# Nine in ten developers are aware of Kubernetes

% of backend developers (Q3 2020 n=5,543 | Q3 2021 n=5,143)



# B. Profile of backend developers using Kubernetes

What do the backend developers who use Kubernetes look like? At the overview level, we define two categories and make a distinction between professionals and non-professionals[5]. **Kubernetes users are professionals to a large extent**: nine in ten of these developers identify as such. Backend developers who don't use Kubernetes are less likely to be professionals: only 73% are. In general, the backend services sector has the highest concentration of professionals (77%) across all sectors we track in our surveys.

Further, we explore the size of organisations that backend developers who use Kubernetes work for — again contrasting with the backend developers who don't use Kubernetes, to gain context. Organisation size categories are given in Appendix A. As a general trend, **the larger an organisation a backend developer works for, the more proportionally likely they are to be using Kubernetes**. Close to one in four developers working for very large enterprises use Kubernetes. The adoption of Kubernetes arguably requires a significant investment of time and resources with the scale and complexity of projects in larger organisations driving the use of container engines. Larger organisations have better resources and use cases to adopt Kubernetes.

In terms of education, **backend developers who use Kubernetes are more likely than those who don't use this technology to be formally educated**: 49% learnt to code by taking an undergraduate degree in computing or software engineering and 27% by taking a postgraduate degree. In comparison, among backend developers who don't use Kubernetes, 43% learnt to code through an undergraduate degree in computing and 17% through a postgraduate degree. In addition, around seven in ten of all backend developers — regardless of whether they use Kubernetes or not — learn to code through self-study.

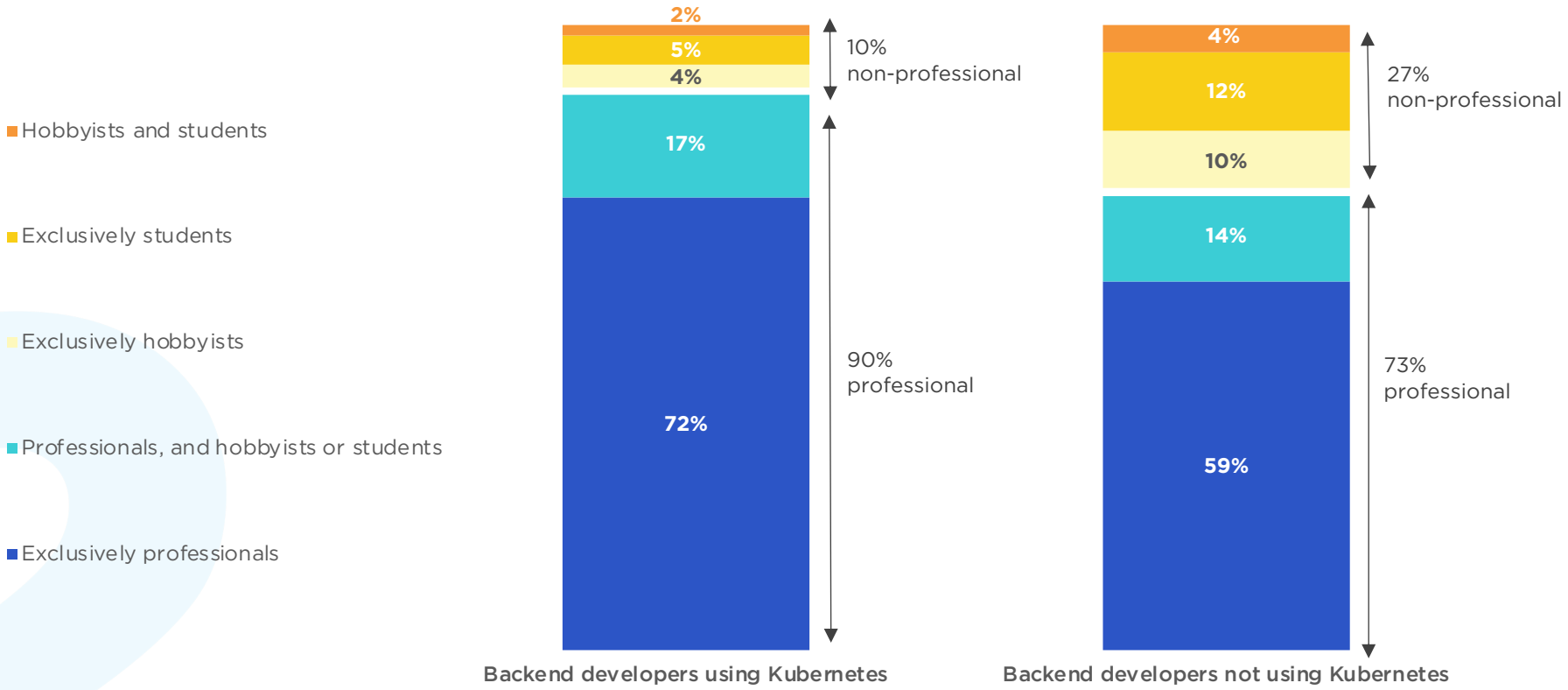
We conclude that Kubernetes developers are more likely to be professionals and to be working for very large enterprises than backend developers who do not use Kubernetes. Heading to the microscope briefly, we see that they are also security-focussed: **one in four backend developers who use Kubernetes have recently chosen to migrate their apps to the cloud due to security reasons**. However, backend developers who do not use Kubernetes are even more likely to migrate due to security; 29% have chosen to do so. We deep dive further into the issue of security in the cloud native space in chapter four.

[5] *If a developer is involved professionally in building backend services, we count them as a professional, regardless of whether they are also a hobbyist or student in that same sector. Non-professionals could be hobbyists, students, or both.*

# 9 in 10 Kubernetes developers are professionals

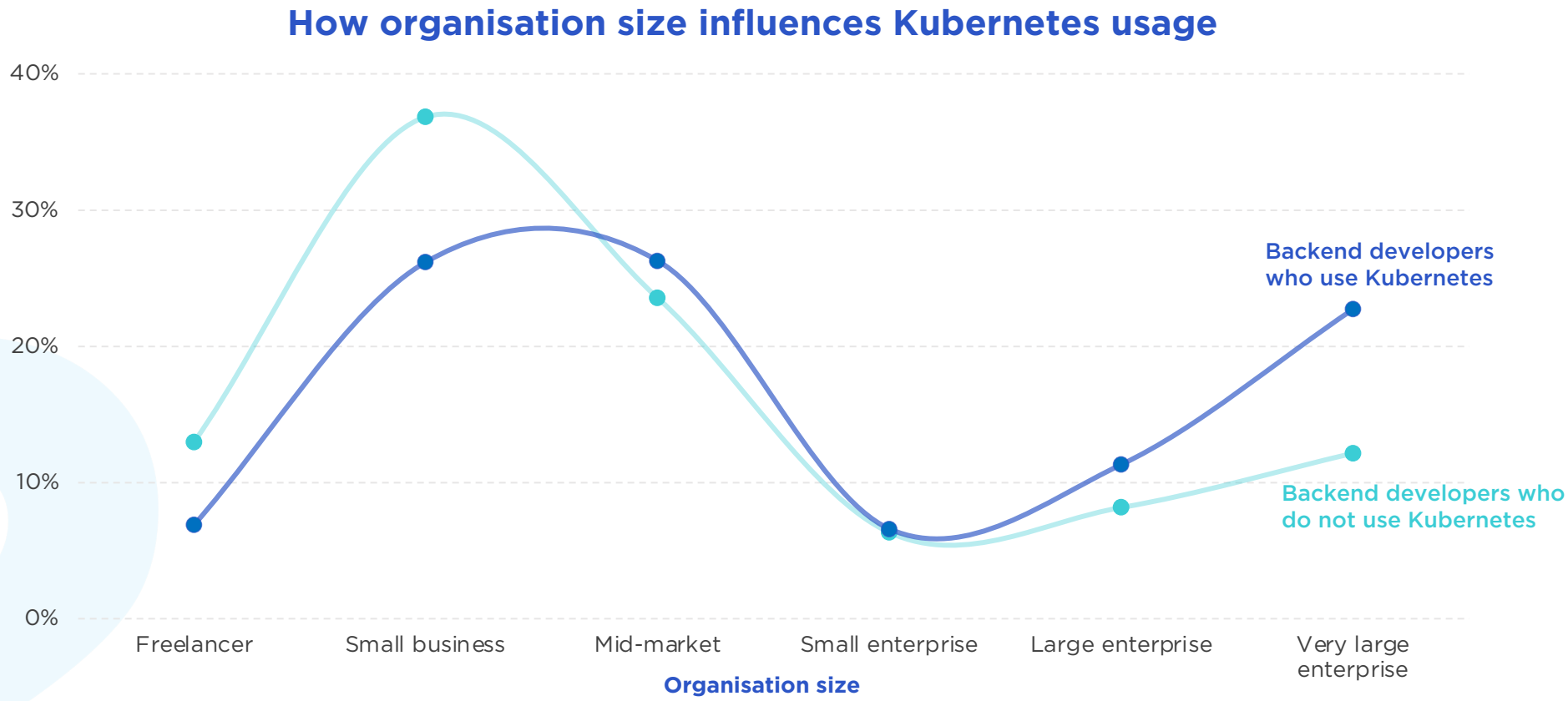
% of backend developers (Q3 2021 n=7,090)

## Mix of professionals and non-professionals in the Kubernetes developer community



# The larger an organisation a backend developer works for, the more proportionally likely they are to be using Kubernetes

% of backend developers by the size of the organisation they work for (Q3 2021 n=5,934)



# C. Does involvement in emerging areas differ according to Kubernetes usage?

In this section, we examine which emerging areas backend developers using Kubernetes are currently working in. These areas include: mini apps, robotics, 5G, quantum computing, fog and edge computing, cryptocurrencies, and other blockchain applications, among others.

**Mini apps, computer vision, blockchain applications, cryptocurrencies, and biometrics for ID verification are the areas with the largest proportion of backend developers using Kubernetes** — more than one in five developers in each of these areas uses Kubernetes.

Backend developers who use Kubernetes are involved in a higher number of emerging areas than their peers who don't use this technology: 48% of Kubernetes users work in two or more emerging areas, while backend developers who don't use Kubernetes are 10 percentage points less likely to work in more than one area.

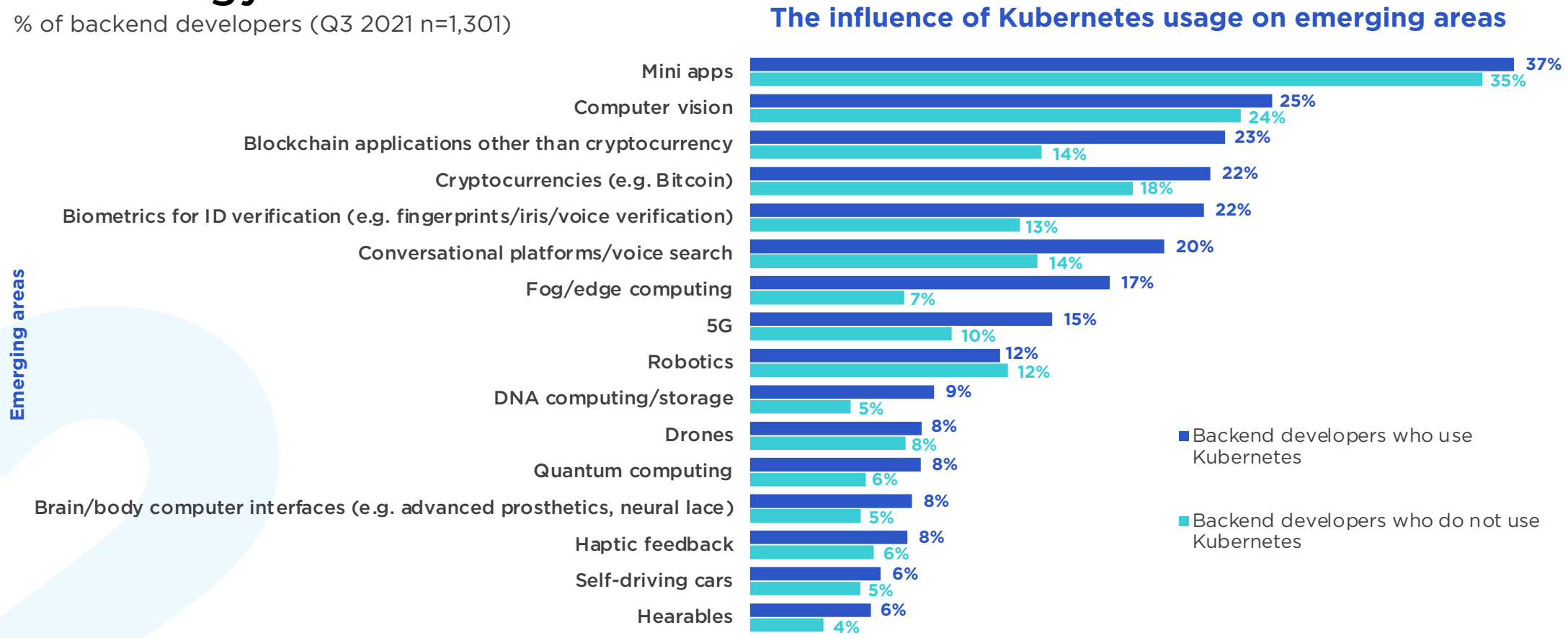
Emerging areas with the largest differential in involvement between backend developers who use Kubernetes and those who don't are fog and edge computing, biometrics for ID verification, and blockchain applications. Developers who use Kubernetes are 9 to 10 percentage points more likely than those who don't to be working in these areas. The usage of Kubernetes in these areas is also growing: biometrics for ID verification and blockchain applications both grew eleven percentage points in popularity among Kubernetes users over the last twelve months, while fog and edge computing grew 3 percentage points[6].

The emerging area with the least differential in involvement is robotics. Whether backend developers use Kubernetes has little effect on their rate of engagement in this area, which sits at 12%[7].

[6] *Our previous report, The State of Cloud Native Development Q1 2021, offered significant insights into edge computing in the cloud native space.*
[7] *There are certain challenges with running the Robot Operating System (ROS) on Kubernetes, including Kubernetes' lack of support for dynamic ports. However, recent work with ROS 2 has proved promising in this area, and as such, this is an interesting emerging area for Kubernetes growth in the future.*

# Backend developers who use Kubernetes are involved in a higher number of emerging areas than their peers who don't use this technology

% of backend developers (Q3 2021 n=1,301)



# 3. Usage Trends of Orchestration and Serverless Tools

# A. Usage of orchestration tools

While Kubernetes has become the industry standard, developers are leveraging it in different ways. Developers might self-host Kubernetes clusters while others use container orchestration services to help manage their Kubernetes clusters. The majority of container orchestration tools — including five of the top six most used — are managed Kubernetes solutions. **The market is strongly shaped by Kubernetes and managed Kubernetes services**.

Overall, **the top three vendors offering managed orchestration services — Amazon, Google, and Microsoft — dominate the market**. 24% of backend developers who use or are aware of any orchestration tool are currently using Amazon's Elastic Container Service (ECS), making it the most widely adopted solution. After a 3 percentage point decline in the last six months, Google Kubernetes Engine (GKE) is in second place, with 21% of developers using it.

Interestingly, 30% of developers using orchestration tools are building their own container management solution or they are self-hosting an existing offering. In the last six months, this proportion has grown by 3 percentage points. These developers are circumventing vendor offerings and might instead be turning towards standalone orchestration engines, such as Kubernetes. Self-managed solutions give developers full control, allowing them to tailor functionalities to their specific needs which may be required for custom systems.

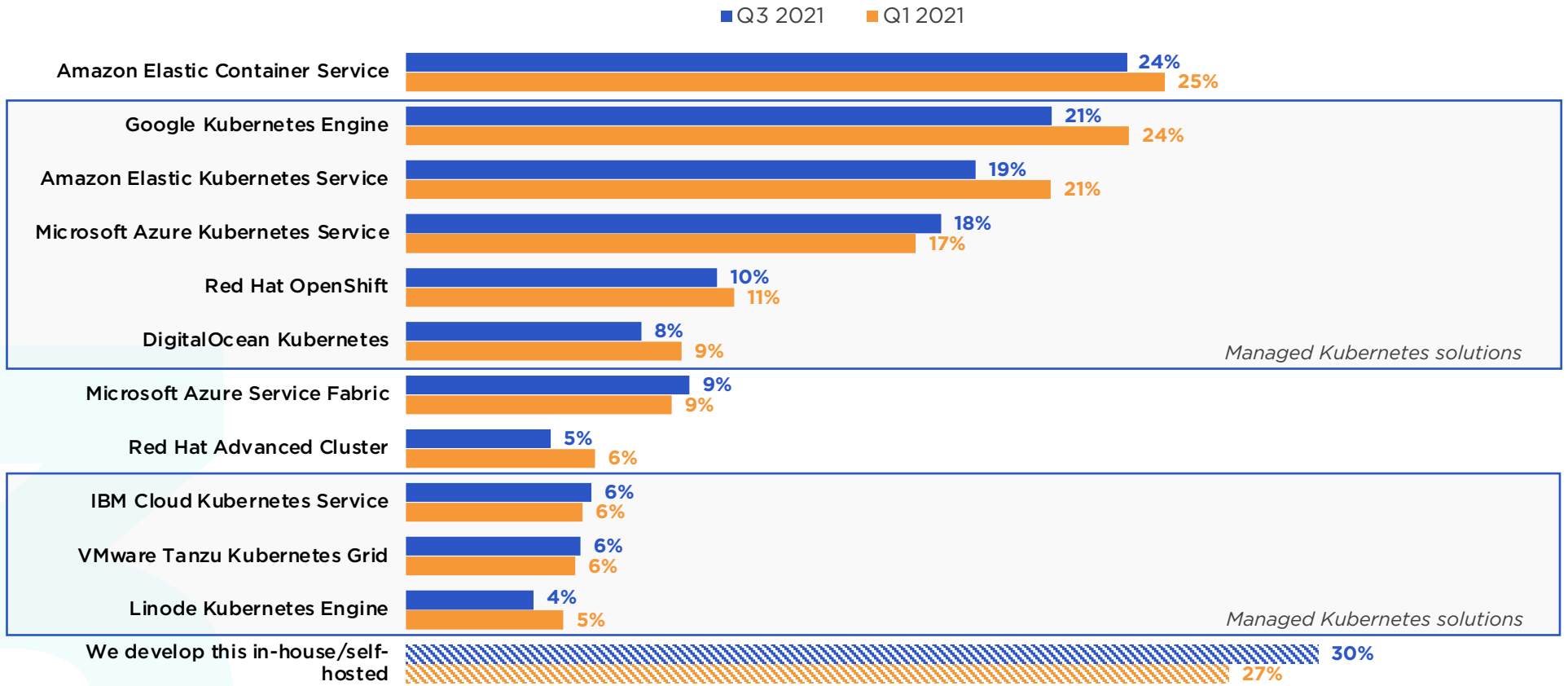
Some developers are finding **the possibility of using a self-managed solution in conjunction with a vendor's offerings particularly appealing**. 42% of developers using Microsoft Azure Service Fabric, 60% of developers using Red Hat Advanced Cluster, and 44% of developers using IBM Cloud Kubernetes Service also build their own container management solution or self host.

Further, **the proportion of developers choosing a single orchestration tool has decreased**: 49% of backend developers who use or are aware of any orchestration tool used only one tool in Q1 2021. Six months later, 46% of these developers use only one tool. More developers are choosing to use multiple orchestration solutions in order to leverage different advantages from each. Briefly scanning the satisfaction scores of these vendor products, no single solution dominates across the attributes important to backend developers who use orchestration tools: pricing, documentation and sample code, technical support, integration with other systems, suitability, and feature set, as well as ease and speed of development.

# Amazon ECS leads the container orchestration market

% of backend developers who use or are aware of any orchestration tool (Q1 2021 n=968 | Q3 2021 n=1,081)

## Usage of orchestration tools over the last six months



# B. Usage of serverless tools

Serverless architecture is lauded for its self-managed, detailed scaling, as well as its automatic resource provisioning. The key benefit is seen as its ability to scale, which is transparent and managed to the level of individual requests. This in turn reduces costs, as developers pay only for the resources they use and there is no need to pay for idle servers. Here, we investigate the landscape of serverless product offerings.

**AWS Lambda is by far the most widely adopted product**, with 43% of backend developers who use serverless architecture choosing to use it. Google's serverless products occupy second place with 29% usage for Google Cloud Functions, and fourth place with 15% usage of Google Cloud Run.

Google Cloud Functions is the established serverless offering from Google. As an example of a Function as a Service (FaaS) product, it offers the typical event-driven function-triggering framework. However, there are only a small set of languages in which one can write code for Google Cloud Functions — JavaScript/Node.js, Python 3, or Go — and it places restrictive constraints on how code is deployed. As an alternative, Google Cloud Run is the vendor's latest serverless offering. A type of serverless container, Google Cloud Run affords impressive flexibility and works cohesively with Google's orchestration tool, GKE. **Google Cloud Run** has been rising in popularity over the couple of years since its launch — as such, it is quite surprising to see **such a dramatic decrease in usage of 6 percentage points from Q1 2021 to Q3 2021**. This decrease might partly be driven by a decrease in usage of GKE by 3 percentage points over the same period[8].

Although less extreme, both AWS Lambda and Google Cloud Functions decreased in usage by 3 percentage points over this six month period. Azure Functions alone remains steady in this trend-decreasing landscape, maintaining 26% usage.

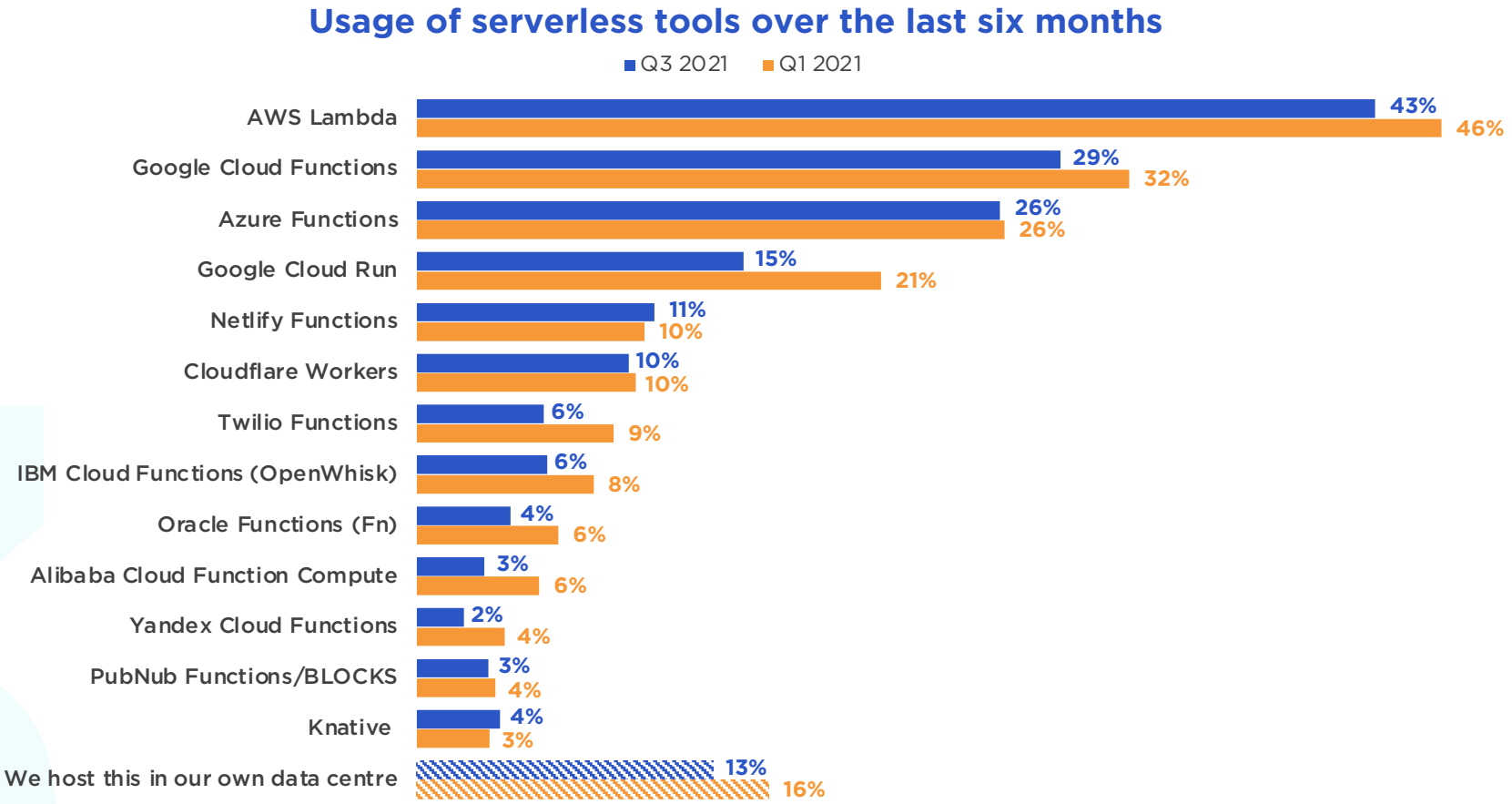
It seems that **the way in which developers engage with serverless products is changing**. In the past, developers would leverage multiple serverless products simultaneously. In Q1 2021, 23% of backend developers who used or were aware of any serverless product used three or more serverless products. Six months later, only 19% of developers do. With developers choosing to use fewer products, **competition in this landscape is set to become fiercer**.

Vendors' hold on serverless architecture is not ubiquitous: 13% of developers who use or are aware of any serverless product choose to host in their own data centres.

[8] *Usage of orchestration tools is discussed in more detail in the previous section.*

# Usage of Google Cloud Run dropped by 6 percentage points in the past six months

% of backend developers who use or are aware of any serverless product (Q1 2021 n=911 | Q3 2021 n=951)



# 4. Security in the Cloud Native Space

# A. Impact on decisions

There are many tiers of cloud native developers: these range from those high up in a business hierarchy that make or influence purchasing decisions, down to developers who are not involved at all in these selections. Here, we show the breakdown of cloud native developers according to economic decision-making power within an organisation and how this differs depending on attitudes towards security. **Those who are more security-focussed** — defined as developers who have recently chosen to migrate their apps to the cloud due to security reasons — **are more likely to be able to affect tooling purchasing decisions**.

32% of security-focussed cloud native developers make the final selection decision for team or company tools. This is 10 percentage points higher than in the general cloud native population. Security-focussed cloud native developers are also significantly more likely to be responsible for specifications, able to approve expenses on tools and the overall team budget for developer tools.

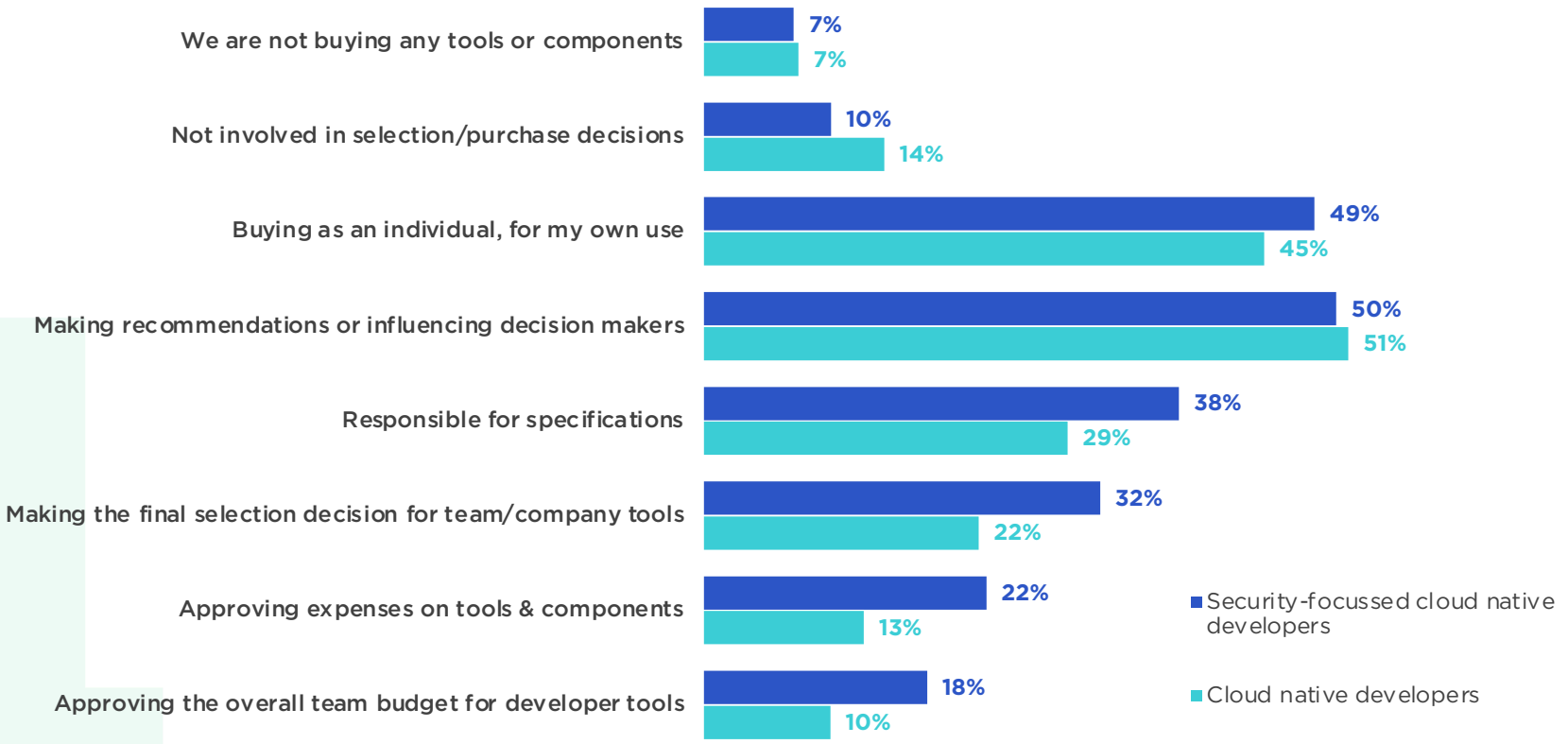
In agreement with this analysis: 10% of security-focussed cloud native developers are not involved in purchasing decisions, while this rises to 14% among cloud native developers in general.

Looking at security in the cloud native landscape from another angle: **security issues are relatively unlikely to affect adoption of serverless tools** — only 6% of cloud native developers would adopt a serverless tool due to security, ranking this consideration 15th out of 17. Similarly, 5% of cloud native developers would reject a serverless tool due to security concerns.

# Security-focussed cloud native developers are more likely to be economic decision-makers

% of cloud native developers that have each level of influence (Q3 2021 n=1,828)

## Cloud native developers' influence on tooling purchasing decisions



# Appendix

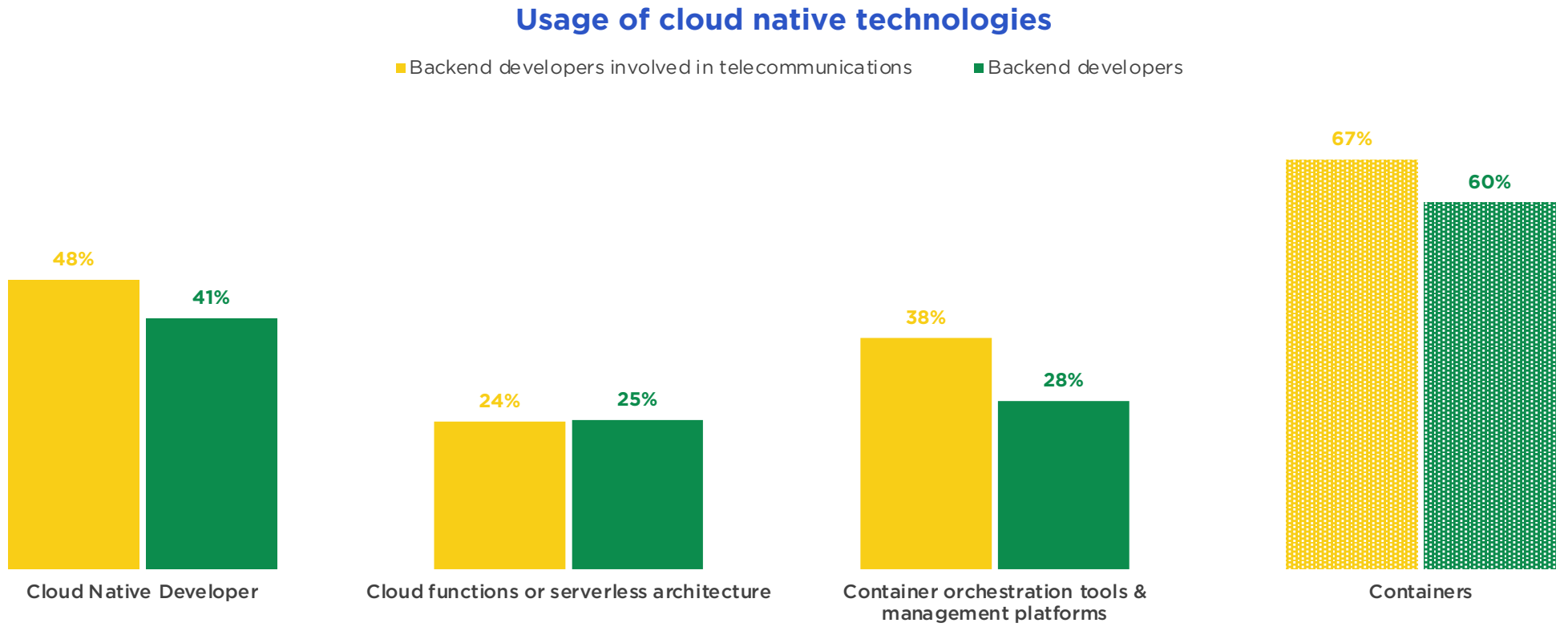
## Appendix A

We asked professional backend developers what size organisation they work for. Defining:

- Freelancer developers as those who work for themselves;
- Small business developers as those who work for organisations with between two and 50 employees;
- Mid-market businesses between 51 and 500 employees;
- Small enterprises between 501 and 1,000 employees;
- Large enterprises between 1,000 and 5,000 employees;
- Very large enterprises with more than 5,000 employees.

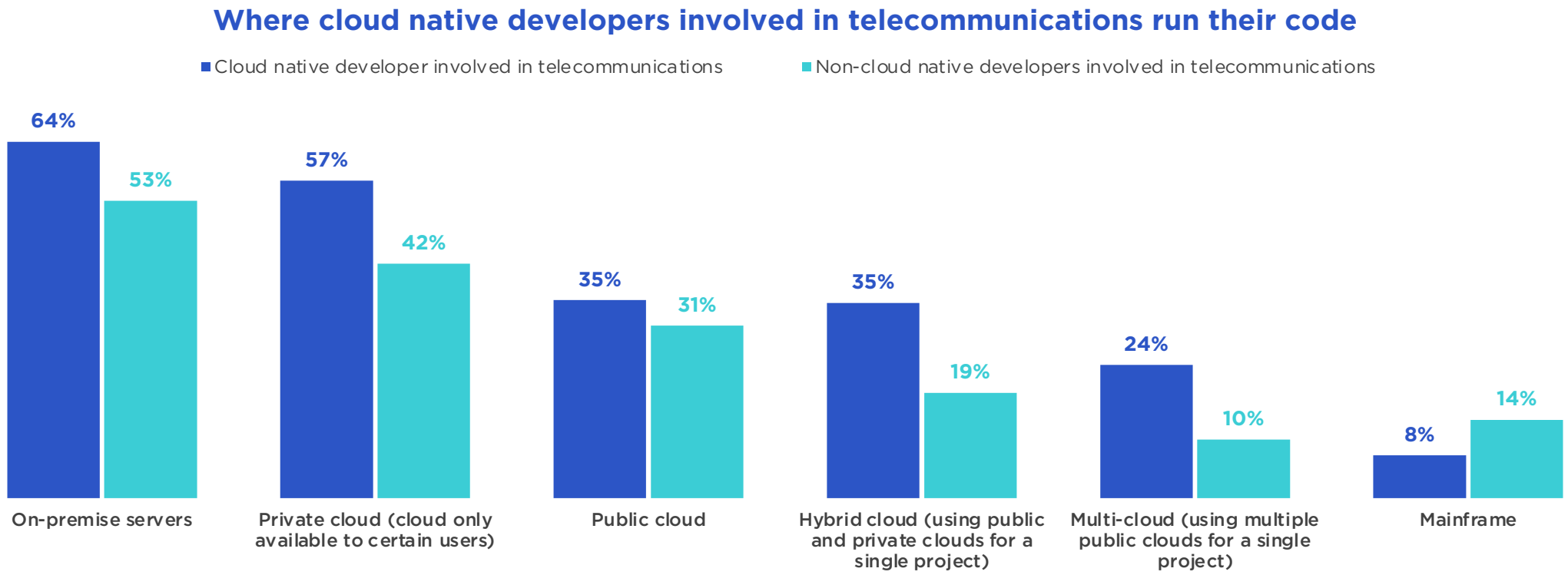
# Telecommunications backend developers are 7 percentage points more likely to be cloud native developers than backend developers in general

% of backend developers (Q3 2021 n=3,941)



# Cloud native developers working in the telecommunications industry leverage a higher number of deployment environments than their non-cloud native peers

% of backend developers involved in telecommunications who use each environment (Q3 2021 n=198)



# METHODOLOGY

## The Developer Economics Survey

Developer Economics 20th edition reached 19,000+ respondents from 155 countries around the world. As such, the Developer Economics series continues to be the most global independent research on mobile, desktop, industrial IoT, consumer electronics, embedded, third party app ecosystems, cloud, web, game, AR/VR, and machine learning developers and data scientists combined, ever conducted. The report is based on a large-scale online developer survey designed, produced, and carried out by SlashData over a period of ten weeks between November 2020 and February 2021.

Our respondents came from a broad age spectrum, from young coders who are under 18 to the seasoned ones over 55.  As software development is still a man's world, 79% of our respondents were male and 20% female, excluding other options and those who did not specify their gender.

Respondents were asked which types of projects they are involved in out of the 13 under study, namely web apps / SaaS, mobile apps, desktop apps, backend services, augmented reality, virtual reality, games, data science, machine learning / artificial intelligence, industrial IoT, consumer electronics devices, embedded software, and apps/extensions for third party ecosystems. They also told us if they are into their areas of involvement as professionals, hobbyists, or students - or as any combination of these - and how many years of experience they have in each.

To eliminate the effect of regional sampling biases, we weighted the regional distribution across eight regions by a factor that was determined by the regional distribution and growth trends identified in our Developer Economy research. Each of the separate branches: mobile, desktop, iIndustrial IoT, consumer electronics, embedded software, third party app ecosystems, cloud, web, games, augmented and virtual reality, and data science and machine learning were weighted independently and then combined.

To minimise other important sampling biases across our outreach channels, we weighted the responses to derive a representative distribution for technologies used and developer segments. Using ensemble modelling methods, we derived a weighted distribution based on data from independent, representative channels, excluding the channels of our research partners to eliminate sampling bias due to respondents who were recruited via these channels.

Again, this was performed separately for each of mobile, industrial IoT, consumer electronics, embedded software, third party app ecosystems, desktop, cloud, web, games, augmented and virtual reality, and data science and machine learning.

For more information on our methodology please visit https://www.slashdata.co/methodology.

TALK TO US WORK WITH US

## We help you understand Developers.

If you could speak to 30,000+ developers what would you ask them?

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