Proposal of Docker and Kubernetes Direction through the Event Timeline of Kubernetes

Seungchan Woo
Protocol Engineering Lab.
Sejong University
Seoul, Republic of Korea
seungchan@pel.sejong.ac.kr

Jong-Hyouk Lee
Dept. of Computer and Information Security &
Convergence Engineering for Intelligent Drone
Sejong University
Seoul, Republic of Korea
jonghyouk@sejong.ac.kr

2023 International Conference on Artificial Intelligence in Information and Communication (ICAIIC) | 978-1-6654-5645-6/23/$31.00 ©2023 IEEE | DOI: 10.1109/ICAIIC57133.2023.10066988

***Abstract*—Modern developers typically run their workloads through cloud-native environments such as Docker and Kubernetes. Docker is a platform that runs and manages containers. With the birth of Docker, interest in containers and technology has grown. As one of the container orchestration tools that control and manage containers running on multiple hosts, Kubernetes has a very large share and is used by many cloud companies, making it the standard for practical container orchestration tools. Therefore, in this paper, by analyzing the Kubernetes event timeline, we present the future direction of Kubernetes and Docker, which are key tools in the cloud-native environment.**

Index Terms*— *Kubernetes, Docker, Event Timeline

I. Introduction

Developers today typically run their workloads through cloud-native environments such as Docker and Kubernetes. With the birth of Docker, which is an open-source platform that runs and manages containers, interest in container technology has grown. Containers are gaining attention from many developers because they are lightweight and use fewer resources than traditional virtual machines.

As developers operate Docker containers on multiple hosts, they needed a way to control and manage multiple containers, and container orchestration tools emerged. As the most popular orchestration tool, Kubernetes has a very large share. It is used by many cloud companies and is becoming a pragmatic standard for container orchestration tools. According to computer software company Flexera's State of the Cloud Report 2022 survey, approximately 42% of developers use Kubernetes and 25% say they plan to use Kubernetes [1]. Considering that cloud services such as Amazon's AWS Elastic Kubernetes Service, Microsoft's Azure Kubernetes Service, Google's Google Kubernetes Engine, and Red Hat's OpenShift are based on Kubernetes, actual usage is expected to be higher.

In this paper, we analyze the event timeline of Kubernetes, which is the center of the cloud-native environment and discuss the future direction of Docker and Kubernetes. The structure of this paper is as follows. Section II shows and describes the event timeline of Kubernetes. Section III presents the future direction of Docker and Kubernetes, and finally, Section IV concludes this paper.

II. Kubernetes Event Timeline

This section first presents a timeline of Kubernetes events as in Figure 1 and details are described below.

A. Major Events in 2014

TABLE I
List of Kubernetes Important Events in 2014

No.	Date	Event	Ref.
1	2014.05.22	Google introduced groud work of Kubernetes as an open source version of Borg	[2]
2	2014.06.07	First github commit for Kubernetes	[3]
3	2014.06.10	Microsoft, RedHat, IBM, Docker joins the Kubernetes community	[4]

2014 was the year Kubernetes was first introduced to the world. On May 22, GCP's Senior Staff Software Engineer Joe Beda presented early research on Kubernetes at the GlueCon 2014 conference. Google started developing Kubernetes as open source written in the Go language, based on its experience developing Borg to manage clusters at headquarters. To develop Kubernetes, cloud service providers have joined the Kubernetes community with the goal of making container technology available to a wide range of developers.

B. Major Events in 2015

TABLE II
List of Kubernetes Important Events in 2015

No.	Date	Event	Ref.
4	2015.07.21	Kubernetes v1.0 released	[5]
5	2015.07.21	Google partnered with the Linux Foundation to form the Cloud Native Computing Foundation	[6]
6	2015.12.03	Cloud Native PaaS products are start to adopt Kubernetes as a foundation	[7]
7	2015.12.09	Kubernetes v1.1 released	[8]

2015 was the year Kubernetes was officially launched and the Cloud Native Computing Foundation was established.

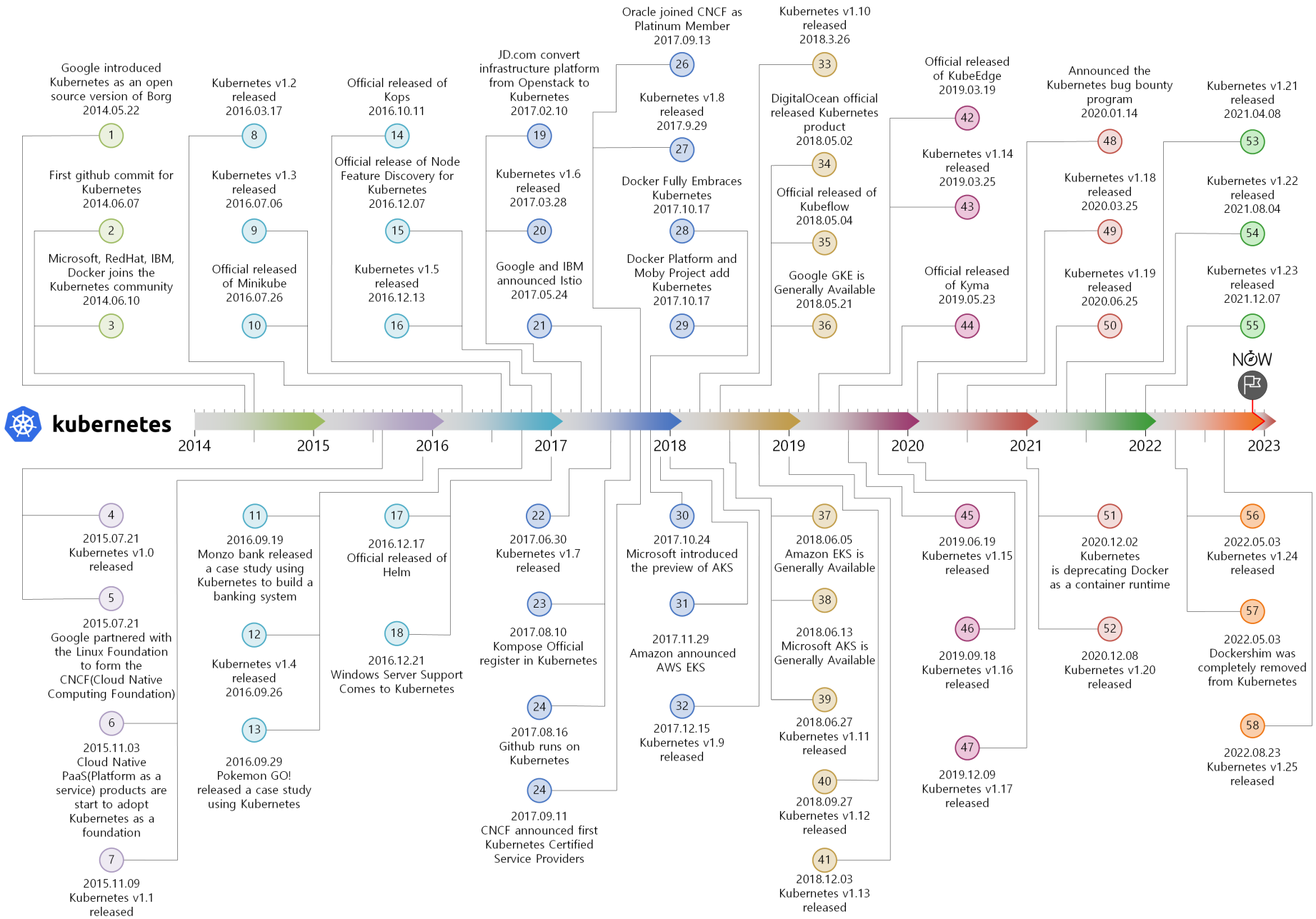

Fig. 1. Kubernetes Event Timeline

Together with the Linux Foundation, Google founded the Cloud Native Computing Foundation and donated Kubernetes. Cloud Native Computing Foundation's Kubernetes is open source and open to non-paid contributions. In November, adoption of cloud service providers' cloud-native Platform as a service (PaaS) offerings based on Kubernetes began. Version 1.1 significantly improves the performance of version 1.0 and adds new features such as horizontal pod autoscaling and an HTTP load balancer.

C. Major Events in 2016

TABLE III
LIST OF KUBERNETES IMPORTANT EVENTS IN 2016

No.	Date	Event	Ref.
8	2016.03.17	Kubernetes v1.2 released	[9]
9	2016.07.06	Kubernetes v1.3 released	[10]
10	2016.07.26	Official release of Minikube	[11]
11	2016.09.19	Monzo bank released a case study using Kubernetes to build a banking system	[12]
12	2016.09.26	Kubernetes v1.4 released	[13]
13	2016.09.29	Pokémon GO! released a case study using Kubernetes	[14]
14	2016.10.11	Official release of Kops	[15]
15	2016.12.07	Official release of Node Feature Discovery for Kubernetes	[16]
16	2016.12.13	Kubernetes v1.5 released	[17]
17	2016.12.17	Official release of Helm	[18]
18	2016.12.21	Windows Server Support Comes to Kubernetes	[19]

2016 was the year that Kubernetes went mainstream. British online bank Monzo presented an example of building a back-end with Kubernetes. AR Game Pokémon Go developed by Niantic was operated by Kubernetes. More and more companies were starting to run their backends with Kubernetes. In 2016, there were four releases from v1.2 to v1.5.

In v1.2, the cluster size increased, and management has been automated. Deployment and management of the application has been simplified and a GUI has been created. In v1.3, the Container Network Interface (CNI) standard was applied, allowing the introduction of container runtime other than Dockers. v1.4 introduced 'kubeadm', which reduces bootstrapping to two commands without complex scripts, and added support for pod security policies and AppArmor to support container security. In v1.5, Kubernetes supported Windows Server and Hyper-V containers. Minikube, which makes it easy to operate Kubernetes in a local environment, kops, which automatically provisions clusters, Node Feature Discovery, which discovers Kubernetes hardware and system configuration, and Kubernetes applications, which make it easy to manage. Helm has been officially released.

D. Major Events in 2017

2017 was the year cloud service companies adopted and upgraded Kubernetes. Chinese web services company JD.com switched its infrastructure platform from VM-based OpenStack to Kubernetes. GitHub switched its infrastructure platform to Kubernetes. Docker fully embraced Kubernetes and added Kubernetes to the Docker platform and the Mobi project. Amazon and Microsoft have announced that they will be adding Kubernetes services to their platforms. In 2017 there were 4 releases from v1.6 to v1.9. During the release, updates focused on the scalability and security of Kubernetes.

TABLE IV
LIST OF KUBERNETES IMPORTANT EVENTS IN 2017

No.	Date	Event	Ref.
19	2017.02.10	JD.com convert infrastructure platform from Openstack to Kubernetes	[20]
20	2017.03.28	Kubernetes v1.6 released	[21]
21	2017.05.24	Google and IBM announced Istio	[22]
22	2017.06.30	Kubernetes v1.7 released	[23]
23	2017.08.10	Kompose Official register in Kubernetes	[24]
24	2017.08.16	Github runs on Kubernetes	[25]
25	2017.09.11	CNCF announced first Kubernetes Certified Service Providers	[26]
26	2017.09.13	Oracle joined CNCF as Platinum Member	[27]
27	2017.09.29	Kubernetes v1.8 released	[28]
28	2017.10.17	Docker Fully Embraces Kubernetes	[29]
29	2017.10.17	Docker Platform and Moby Project add Kubernetes	[30]
30	2017.10.24	Microsoft introduced the preview of AKS (Azure Kubernetes Service)	[31]
31	2017.11.29	Amazon announced AWS EKS (Elastic Kubernetes Service)	[32]
32	2017.12.15	Kubernetes v1.9 released	[33]

E. Major Events in 2018

TABLE V
LIST OF KUBERNETES IMPORTANT EVENTS IN 2018

No.	Date	Event	Ref.
33	2018.03.26	Kubernetes v1.10 released	[34]
34	2018.05.02	DigitalOcean official released Kubernetes product	[35]
35	2018.05.04	Official released of Kubeflow	[36]
36	2018.05.21	Google GKE (Google Kubernetes Engine) is Generally Available	[37]
37	2018.06.05	Amazon EKS (Elastic Kubernetes Service) is Generally Available	[38]
38	2018.06.13	Microsoft AKS (Azure Kubernetes Service) is Generally Available	[39]
39	2018.06.27	Kubernetes v1.11 released	[40]
40	2018.09.27	Kubernetes v1.12 released	[41]
41	2018.12.03	Kubernetes v1.13 released	[42]

2018 was the year when the big three clouds applied Kubernetes services to their companies in earnest. Between May and June, DigitalOcean announced Kubernetes products, and the Big 3 Cloud companies announced full adoption of Kubernetes services, in that order: GKE, EKS, and AKS. Kubeflow, a service for simply porting and deploying Kubernetes machine learning workflows, has been officially announced. In 2018, there were a total of 4 releases from v1.10 to v1.13. During the release, Kubernetes was stabilized and simplified in terms of storage, security, and network.

F. Major Events in 2019

TABLE VI
LIST OF KUBERNETES IMPORTANT EVENTS IN 2019

No.	Date	Event	Ref.
42	2019.03.19	Official released of KubeEdge	[43]
43	2019.03.25	Kubernetes v1.14 released	[44]
44	2019.05.23	Official released of Kyma	[45]
45	2019.06.19	Kubernetes v1.15 released	[46]
46	2019.09.18	Kubernetes v1.16 released	[47]
47	2019.12.09	Kubernetes v1.17 released	[48]

2019 was a year of stabilization for Kubernetes. Kubernetes is getting more and more stable, but there are still projects that support various features in Kubernetes. Kyma, an application runtime that makes it easy to extend and deploy Kubernetes, and KubeEdge, an open-source system that builds on Kubernetes to provide core infrastructure support for networking, application deployment, and metadata synchronization between the cloud and the edge, was officially announced. In 2019, there are a total of 4 releases from v1.14 to v1.17. During the release, Kubernetes improved scalability and added features such as volume expansion.

G. Major Events in 2020

TABLE VII
LIST OF KUBERNETES IMPORTANT EVENTS IN 2020

No.	Date	Event	Ref.
48	2020.01.14	Announced the Kubernetes bug bounty program	[49]
49	2020.03.25	Kubernetes v1.18 released	[50]
50	2020.06.25	Kubernetes v1.19 released	[51]
51	2020.12.02	Kubernetes is deprecating Docker as a Container Runtime	[52]
52	2020.12.08	Kubernetes v1.20 released	[53]

From 2020, there are 3 releases from v1.18 to v1.20. During the release, Kubernetes has been stabilized for a better user-focused experience. Kubernetes has declared that it will deprecate Docker as a container runtime after v1.20.

H. Major Events in 2021 & 2022

TABLE VIII
LIST OF KUBERNETES IMPORTANT EVENTS IN 2021 & 2022

No.	Date	Event	Ref.
53	2021.04.08	Kubernetes v1.21 released	[54]
54	2021.08.04	Kubernetes v1.22 released	[55]
55	2021.12.07	Kubernetes v1.23 released	[56]
56	2022.05.03	Kubernetes v1.24 released	[57]
57	2022.05.03	Dockershim was completely removed from Kubernetes	[58]
58	2022.08.23	Kubernetes v1.25 released	[59]

As the Kubernetes project matures since 2021, the release cycle has been reduced from four per year to three per year. Since 2021, there have been five releases from v1.21 to v1.23, and stabilization and security operations have been continuously carried out. From Kubernetes v1.24 to v1.20 the discontinued dockershim has been completely removed.

III. THE FUTURE DIRECTION OF DOCKER AND KUBERNETES

The Kubernetes project began after the birth of the Docker container. As docker containers began to attract attention in the market, Kubernetes was created to control and manage docker containers of several hosts. Therefore, in earlier versions of Kubernetes, it only worked with a specific container runtime, Docker Engine. However, since Kubernetes v1.3, Kubernetes has added support for other container runtimes. The Container Runtime Interface (CRI) standard was created to enable interoperability between container orchestrators and container runtime. The early Kubernetes cluster worker node's agent kubelet and Docker was integrated, requiring a deep understanding of kubelet and incurring a significant overhead in the Kubernetes community. Thus, Kubernetes created a CRI to provide a clearly defined layer of abstraction, allowing developers to focus on building container runtime. Because Docker Engine did not implement CRI, the Kubernetes project created a special code dockershim for using Docker, which has so far used Docker as a container runtime.

However, maintaining dockershim only for Dockers was a burden for Kubernetes maintainers, and as incompatible features with Dockershim such as cgroups v2 and user namespace are being implemented in the latest CRI runtime, further development is possible in the area. Although Kubernetes stopped supporting Docker, because Docker is also the most popular container runtime, a plan was developed to continue using Docker in Kubernetes. Docker inc. and Mirantis have developed a core for docker engines capable of docker control through a CRI called cri-dockered [60]. cri-dockered allows shim code to be independently executed outside of Kubernetes, allowing Kubernetes to be built based on the Docker engine. However, features incompatible with Docker engines will continue to be released on Kubernetes, and running dockershim outside Kubernetes can pose a security threat. Therefore, in the future direction of Docker and Kubernetes, both Kubernetes and Docker will go further, but the relationship between the two will become increasingly distant.

IV. CONCLUSION

In this paper, we analyzed the Kubernetes event timeline and present the future direction of Docker and Kubernetes. According to CNCF's Anniversary 2021, 96% of organizations worldwide are already using or reviewing Kubernetes [61]. Kubernetes began to orchestrate docker containers, but now Kubernetes has become an irreplaceable open-source platform and is considered a practical standard. By investigating Kubernetes' event timeline, we could know about Kubernetes' events and development directions briefly. Attention will be paid to Docker's move, which has become unsupported by Kubernetes.

ACKNOWLEDGMENT

This work was supported by Institute of Information & communications Technology Planning & Evaluation (IITP) grant funded by the Korea government (MSIT) (No.2021-0-01806, Development of security by design and security management technology in smart factory).

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