Study Protocol

Research questions

RQ1	What are the smells indicating possible security violations in microservice-based applications?
RQ2	How to refactor microservice-based applications to mitigate the effects of security smells therein?

White Literature Search

Database	Search String	Results	
ACM Digital Library	microservice* AND s	101	
DBLP	microservice securit	1	
IEEE Xplore	microservic* AND se	4	
ISI Web of Science	ALL=(microservice*	2	
Science Direct	microservice AND s	68	
Scopus	microservice AND s	129	
SpringerLink	microservic* AND se	629	
Google Scholar	(microservice) AND	169	(restricted to scientific articles)

Grey Literature Search

Search Engines	(effort bounded: first 250 hits)		
Query	**Google**	**Bing**	**DuckDuckGo**
microservice security sm	250	250	250
microservice security an	250	250	250
microservice security ba	250	250	250
microservice security pit	250	250	250
microservice security ref	250	250	250
microservice security ree	250	250	250
microservice security res	250	250	250
Results	6353		

Inclusion criteria

A study is selected if published between 01/01/2011 and 31/12/2020
A study is to be selected if it is written in English.
A study is to be selected if it qualifies as white literature, or as a blog post, whitepaper, industrial magazine publication, or video authored by a practitioner.
A study is to be selected if it focuses on microservices.
A study is to be selected if it focuses on security.

A study is selected if it presents at least one security smell possibly resulting in a violation of a security property defined by the ISO/IEC 25010 standard
A study is selected if it presents at least one refactoring for mitigating the effects of a security smell, even if the latter is not explicitly mentioned.

Coding Schema
type (white/grey)
sub-type [white] conference vs journal paper vs book chapter | [grey] blog post vs video vs whitepaper vs documentation
authors
title
publication venue: [white] bibliographic information | [grey] name of the blog/news (e.g., TechBeacon, Medium), video hosting service, …
year
URL/link
Search engine

Candidate Literature (Inclusion/Exclusion)

Authors	Title	Venue	Year	Type	Sub-Type	Search engine	Francisco	Jacopo	IRR	ALL	Link
Marco Troisi	8 best practices for microservices app sec	TechBeacon	2017	Grey	Blog post	Google	Included	Included	1	Included	https://techbeacon.com/app-dev-testing/8-best-practices-microservices-app-sec
~~Jack Mannino~~	~~Security In A Microservice World~~	~~OWASP~~	~~2017~~	~~Grey~~	~~Presentation (PPT)~~	~~Google~~	Excluded	Excluded	1	Excluded	~~https://owasp.org/www-pdf-archive/Microservice_Security.pdf~~
Jack Mannino	Security In The Land Of Microservices	AppSec EU 2017	2017	Grey	Video	Google	Included	Included	1	Included	https://www.youtube.com/watch?v=JRmWlLY8MGE
Zach Gardner	Security in the Microservices Paradigm	Dzone	2017	Grey	Blog post	Google	Excluded	Included	0	Included	https://dzone.com/articles/security-in-the-microservices-paradigm
~~Tim Leytens~~	~~API security in a microservices architecture~~	~~Medium~~	~~2019~~	~~Grey~~	~~Blog post~~	~~Google~~	Excluded	Excluded	1	Excluded	https://medium.com/@timleytens/api-security-in-a-microservices-architecture-2ef673e807c
Sumo Logic	Improving Security in Your Microservices Architecture	Sumo Logic	2019	Grey	Blog post	Google	Included	Included	1	Included	https://www.sumologic.com/insight/microservices-architecture-security/
~~Mick Knutson, Robert Winch, Peter Mularien~~	~~Spring Security: Secure your web applications, RESTful services~~	~~Packt~~	~~2017~~	~~Grey~~	~~Book~~	~~Google~~	Excluded	Excluded	1	Excluded	https://books.google.cl/books?id=MkBPDwAAQBAJ&pg=PA434&lpg=PA434&dq=microservice+restructur
Thribhuvan Krishnamurthy	Transition to Microservice Architecture - Challenges	Beingtechie	2018	Grey	Blog post	Google	Included	Included	1	Included	https://www.beingtechie.io/blog/transition-to-microservices-challenges

Stefano Di Paola	Microservices Security: Dos and Dont's	Minded Security	2018	Grey	Blog post	Google	Excluded	Included	0	Excluded	https://blog.mindedsecurity.com/2018/07/microservices-dos-and-donts.html
Vinay Sahni	Best Practices for Building a Microservice Architecture	Vinay Sahni	2019	Grey	Blog post	Google	Excluded	Included	0	Included	https://www.vinaysahni.com/best-practices-for-building-a-microservice-architecture
John Kinsella, Cem Gurkok, Frank Geck	Challenges in Securing Application Containers and Microservices	Cloud Security Alliance	2019	Grey	Whitepaper	Google	Included	Excluded	0	Excluded	https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&cad=rja&uact=8&ved=2ahUKEwjr
Eric Boersma	Top 10 security traps to avoid when migrating from a monolith to microservices	Sqreen	2019	Grey	Blog post	Google	Included	Included	1	Included	https://blog.sqreen.com/top-10-security-traps-to-avoid-when-migrating-from-a-monolith-to-
Joel Suomalainen	DEFENSE IN DEPTH METHODS IN MICROSERVICES ACCESS CONTROL	Tampere University	2019	Grey	Master's Thesis	Google	Excluded	Excluded	1	Excluded	https://tropo.tuni.fi/bitstream/handle/123456789/27172/suomalainen.pdf?sequence=4&isAllowed=y
Lambda Test	Does Microservices Architecture Influence Security Testing?	Lambda Test	2018	Grey	Blog post	Google	Excluded	Excluded	1	Excluded	https://www.lambdatest.com/blog/does-microservices-architecture-influence-security-testing/
Brian Pitta	What Do Microservices Mean for AppSec?	veracode	2017	Grey	Blog post	Google	Excluded	Excluded	1	Excluded	https://www.veracode.com/blog/managing-appsec/what-do-microservices-mean-
Len Fernandez	42Crunch Announces Full Kubernetes Support to Automate Zero Trust API Security Across Microservices Architecture	prnewswire	2019	Grey	Blog post	Google	Excluded	Excluded	1	Excluded	https://www.prnewswire.com/news-releases/42crunch-announces-full-kubernetes-support-to-automate-zero-
Haim Helman	Scaling Microservices Poses Serious Security Challenges: Haim Helman	TFiR	2019	Grey	Video	Google	Excluded	Included	0	Excluded	https://youtu.be/GAVpE_gQetI

John Carnell	Securing your microservices	Manning	2017	Grey	Book chapter	Google	Included	Included	1	Included	https://livebook.manning.com/book/spring-microservices-in-action/chapter-
WALLARM	A CISO's GUIDE TO CLOUD APPLICATION SECURITY	WALLARM	2019	Grey	Whitepaper	Google	Excluded	Excluded	1	Excluded	https://wallarm.com/files/resources/CISOs%20Guide%20to%20AppSec.pdf
~~Stephen Doxsee~~	~~Implementing Microservices Security Patterns and Protocols with Spring Security~~	~~InfoQ~~	~~2020~~	~~Grey~~	~~Video~~	~~Google~~	Excluded	Excluded	1	Excluded	https://www.infoq.com/presentations/microservices-spring-security-5-1/?itm_campaign=rightbar
Ramaswamy Chandramouli	Security Strategies for Microservices-based Application Systems	NIST	2019	Grey	Whitepaper	Google	Included	Included	1	Included	https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.800-204.pdf
Matt Raible	Security Patterns for Microservice Architectures	Okta	2020	Grey	Blog post	Google	Duplicate	Duplicate	1	Excluded	https://developer.okta.com/blog/2020/03/23/microservice-security-patterns
Edureka	Microservices Security | Best Practices To Secure Microservices | Edureka	edureka!	2019	Grey	Video	Google	Included	Included	1	Included	https://youtu.be/wpA0N7kHaDo
Sam Newman	Security and Microservices by Sam Newman	Devoxx	2016	Grey	Video	Google	Included	Included	1	Included	https://youtu.be/ZXGaC3GR3zU
~~Joe Grandja~~	~~Implementing Microservices Security Patterns and Protocols with Spring Security~~	~~SpringDeveloper~~	~~2019~~	~~Grey~~	~~Video~~	~~Google~~	Excluded	Excluded	1	Excluded	https://youtu.be/JnYIsvJY7gM
~~Adib Saikali~~	~~Microservices Security with Spring~~	~~SpringDeveloper~~	~~2016~~	~~Grey~~	~~Video~~	~~Google~~	Excluded	Excluded	1	Excluded	https://youtu.be/cKjgkNt-tFg

~~Herman Leybovich~~	~~Microservices for Military Applications~~	~~HashiCorp~~	~~2019~~	~~Grey~~	~~Video~~	~~Google~~	Excluded	Excluded	1	Excluded	https://youtu.be/a-Fnnq1h_T8
~~David Blevins~~	~~David Blevins — Deconstructing REST Security, Iterate 2018~~	~~OktaDev~~	~~2018~~	~~Grey~~	~~Video~~	~~Google~~	Included	Excluded	0	Excluded	https://youtu.be/XuhKdy7UIoY
~~Dallas Monson~~	~~Microservices Anti-Patterns~~	~~Dzone~~	~~2019~~	~~Grey~~	~~Blog post~~	~~Google~~	Excluded	Excluded	1	Excluded	https://dzone.com/articles/microservices-anti-patterns
Michael Hofmann, Erin Schnabel, Katherine	Application security - Microservices Best Practices for Java	IBM Redbooks	2016	Grey	Book chapter	Google	Included	Included	1	Included	https://books.google.cl/books?id=KdSrDQAAQBAJ&pg=PA71&lpg=PA71&dq=microservice+antipattern+s
Vinicius Feitosa Pacheco	Microservice Patterns and Best Practices	Packt	2018	Grey	Book	Google	Included	Included	1	Included	https://books.google.cl/books?id=oyZKDwAAQBAJ&pg=PA142&lpg=PA142&dq=microservice+antipattern
~~NCSC~~	~~Security architecture anti-patterns~~	~~NCSC~~	~~2019~~	~~Grey~~	~~Whitepaper~~	~~Google~~	Excluded	Excluded	1	Excluded	https://www.ncsc.gov.uk/whitepaper/security-architecture-anti-patterns
~~Arif Khan~~	~~Microservices: The Good, the Bad, and the Ugly~~	~~Dzone~~	~~2018~~	~~Grey~~	~~Blog post~~	~~Google~~	Excluded	Excluded	1	Excluded	https://dzone.com/articles/microservices-the-good-the-bad-and-the-ugly
Arif Khan	How to Secure Your Microservices — Shopify Case Study	Dzone	2018	Grey	Blog post	Google	Included	Included	1	Included	https://dzone.com/articles/bountytutorial-microservices-security-how-to-secur
Rodrigo Candido da Silva	Best Practices to Protect Your Microservices Architecture	Medium	2017	Grey	Blog post	Google	Included	Included	1	Included	https://medium.com/@rcandidosilva/best-practices-to-protect-your-microservices-architecture-541e7cf7637f

~~Ashan Fernando~~	~~What I have learned Architecting Microservices~~	~~Hackernoon~~	~~2018~~	~~Grey~~	~~Blog post~~	~~Google~~	Excluded	Excluded	1	Excluded	https://hackernoon.com/what-i-have-learned-architecting-microservices-cbccc2182530
Scott Matteson	10 tips for securing microservice architecture	Techrepublic	2017	Grey	Blog post	Google	Included	Included	1	Included	https://www.techrepublic.com/article/10-tips-for-securing-microservice-architecture/
Radware	Microservice Architectures Challenge Traditional Security Practices	Radware	2020	Grey	Blog post	Google	Included	Excluded	0	Included	https://blog.radware.com/security/2020/01/microservice-architectures-challenge-traditional-security-
Joydip Kanjilal	4 fundamental microservices security best practices	SearchAppArchitecture	2020	Grey	Blog post	Google	Included	Included	1	Included	https://searchapparchitecture.techtarget.com/tip/4-fundamental-microservices-security-best-practices
Scott Matteson	How to establish strong microservice security using SSL, TLS and API gateways	Techrepublic	2017	Grey	Blog post	Google	Included	Included	1	Included	https://www.techrepublic.com/article/how-to-establish-strong-microservice-security-using-ssl-tls-and-
~~Warwick Ashford~~	~~Microservices introduce hidden security complexity, analyst warns~~	~~Computer Weekly~~	~~2019~~	~~Grey~~	~~Blog post~~	~~Google~~	Excluded	Excluded	1	Excluded	https://www.computerweekly.com/news/252462690/Microservices-introduce-hidden-security-complexity-
Prabath Siriwardena, Nuwan Dias	Microservices security in action	Manning	2020	Grey	Book	Google	Included	Included	1	Included	https://livebook.manning.com/book/microservices-security-in-action/welcome/v-7/
Matt McLarty, Rob Wilson, and Scott Morrison	Securing Microservice APIs	O'Reilly	2018	Grey	Book	Google	Included	Included	1	Included	https://secureservercdn.net/198.71.233.44/e3z.729.myftpupload.com/wp-content/uploads/2020/01/
Farshad Abasi	Securing modern API- and microservices-based apps by design	IBM	2019	Grey	Blog post	Google	Included	Included	1	Included	https://developer.ibm.com/technologies/api/articles/securing-modern-api-and-microservices-apps-1/

BILL DOERRFELD	How To Control User Identity Within Microservices	Nordic Apis	2018	Grey	Blog post	Google	Excluded	Included	0	Included	https://nordicapis.com/how-to-control-user-identity-within-microservices/
Natasha Gupta	Security Strategies for DevOps, APIs, Containers and Microservices	Imperva	2018	Grey	Blog post	Google	Included	Included	1	Included	https://www.imperva.com/blog/security-strategies-for-devops-apis-containers-and-microservices/
Renata Budko	Five Things You Need to Know About API Security	TheNewStack	2018	Grey	Blog post	Google	Included	Included	1	Included	https://thenewstack.io/5-things-you-need-to-know-about-api-security/
~~Ruth Reinicke~~	~~Authorization and Authentication with Microservices~~	~~LeanIX~~	~~2017~~	~~Grey~~	~~Blog post~~	~~Google~~	Excluded	Excluded	1	Excluded	https://www.leanix.net/en/blog/authorization-authentication-with-microservices
~~Outpost24~~	~~Improve Security of Docker, Containers, and Microservices~~	~~Outpost24~~	~~2017~~	~~Grey~~	~~Blog post~~	~~Google~~	Excluded	Excluded	1	Excluded	https://outpost24.com/blog/Improve-Security-Docker-Containers-Microservices
WALLARM	Shift to Microservices: Evolve Your Security Practices & Container Security	WALLARM	2019	Grey	Blog post	Google	Included	Included	1	Included	https://lab.wallarm.com/shift-to-microservices-evolve-your-security-practices-container-security/
~~Aater Suleman~~	~~Living In A Microservice World: Why Kubernetes Security Matters~~	~~Forbes~~	~~2019~~	~~Grey~~	~~Blog post~~	~~Google~~	Excluded	Excluded	1	Excluded	https://www.forbes.com/sites/forbestechcouncil/2019/02/21/living-in-a-microservice-world-why-
Michael Douglass	Microservices Authentication & Authorization Best Practice	CodeBurst	2018	Grey	Blog post	Google	Included	Included	1	Included	https://codeburst.io/i-believe-it-really-depends-on-your-environment-and-how-well-protected-the-
~~John Au-Yeung~~	~~Best practices for REST API design~~	~~Stack Overflow~~	~~2020~~	~~Grey~~	~~Blog post~~	~~Google~~	Excluded	Excluded	1	Excluded	https://stackoverflow.blog/2020/03/02/best-practices-for-rest-api-design/

Rami Sass	Security in the world of microservices	ITProPortal	2017	Grey	Blog post	Google	Included	Included	1	Included	https://www.itproportal.com/features/security-in-the-world-of-microservices/
~~Sekwon Choi~~	~~How Netflix brings safer and faster streaming experiences to the living room on crowded networks using TLS 1.3~~	~~Netflix Technology Blog~~	~~2020~~	~~Grey~~	~~Blog post~~	~~Google~~	Excluded	Excluded	1	Excluded	https://netflixtechblog.com/how-netflix-brings-safer-and-faster-streaming-experience-to-the-living-
Scott Behrens and Bryan Payne	Starting the Avalanche. Application DDoS In Microservice Architectures	Netflix Technology Blog	2017	Grey	Blog post	Google	Included	Included	1	Included	https://netflixtechblog.com/starting-the-avalanche-640e69b14a06
~~Ryan Bagnulo~~	~~Securing the Microservices Mesh With an API Gateway~~	~~Akana~~	~~2018~~	~~Grey~~	~~Blog post~~	~~Google~~	Excluded	Excluded	1	Excluded	https://www.akana.com/blog/securing-microservices-mesh-api-gateway
~~Darrin Solomon~~	~~Have a safe microservice journey!~~	~~MuleSoft~~	~~2019~~	~~Grey~~	~~Blog post~~	~~Google~~	Excluded	Excluded	1	Excluded	https://blogs.mulesoft.com/dev/microservices-dev/safe-microservice-journey/
~~ThreatAware~~	~~Security by design: how does it work in practice?~~	~~ThreatAware~~	~~2019~~	~~Grey~~	~~Blog post~~	~~Google~~	Excluded	Excluded	1	Excluded	https://threataware.com/security-by-design-how-does-it-work-in-practice/
Scott Behrens, Bryan Payne	Starting the Avalanche: Application DDoS in Microservice Architectures	Netflix Tech Blog	2017	Grey	Blog post	Google	Included	Included	1	Included	https://netflixtechblog.com/starting-the-avalanche-640e69b14a06
VIRAG MODY	From Zero to Zero Trust	Gravitational	2020	Grey	Blog post	Google	Included	Excluded	0	Included	https://gravitational.com/blog/zero-to-zero-trust/
~~Eric Sheridan~~	~~Microservices Security~~	~~WhiteHatSec~~	~~2019~~	~~Grey~~	~~Blog post~~	~~Google~~	Excluded	Excluded	1	Excluded	https://www.whitehatsec.com/blog/microservices-security/

Aaron Parecki	OAuth: When Things Go Wrong	OktaDev	2019	Grey	Video	Google	Included	Included	1	Included	https://www.youtube.com/watch?v=H6MxsFMAoP8
~~Keith Casey, Matt Raible~~	~~Oktane18: API and Microservices Best Practices~~	~~Okta~~	~~2018~~	~~Grey~~	~~Video~~	~~Google~~	Excluded	Excluded	1	Excluded	https://www.youtube.com/watch?v=paEIeZyeJyI
~~Andrew Slivker~~	~~API Security Challenges and How to Address Them~~	~~Nordic APIs~~	~~2018~~	~~Grey~~	~~Video~~	~~Google~~	Excluded	Excluded	1	Excluded	https://www.youtube.com/watch?v=gMEUAwztRMA&feature=emb_logo
Tom Smith	How to Secure APIs	Dzone	2019	Grey	Blog post	Google	Included	Included	1	Included	https://dzone.com/articles/how-to-secure-apis
~~Ben Sigelman~~	~~What We Got Wrong: Lessons from the Birth of Microservices~~	~~InfoQ~~	~~2019~~	~~Grey~~	~~Video~~	~~Google~~	Excluded	Excluded	1	Excluded	https://www.infoq.com/presentations/google-lessons-microservices/
Gerry Gebel and David Brossard	Webinar: Securing APIs and Microservices with OAuth, OpenID Connect, and ABAC	Axiomatics	2018	Grey	Video	Google	Included	Included	1	Included	https://www.youtube.com/watch?v=TnCPJUV9RnA
~~Joan Louis Monteiro, David Blevins~~	~~Implementing Microservice Security via JWT and MicroProfile~~	~~Oracle Developers~~	~~2019~~	~~Grey~~	~~Video~~	~~Google~~	Excluded	Excluded	1	Excluded	https://youtu.be/_iB9SVjWuo8
~~Phil Wittmer~~	~~The Top Microservices Disadvantages & Advantages~~	~~Tiempo Development~~	~~2019~~	~~Grey~~	~~Blog post~~	~~Google~~	Excluded	Excluded	1	Excluded	https://www.tiempodev.com/blog/disadvantages-of-a-microservices-architecture/
~~Srinath Perera~~	~~Walking the Microservices Path Towards Loose Coupling? Look out for These Pitfalls~~	~~Dzone~~	~~2016~~	~~Grey~~	~~Blog post~~	~~Google~~	Excluded	Excluded	1	Excluded	https://dzone.com/articles/walking-the-microservices-path-towards-loose-coupl

Srinath Perera	Walking the wire: Mastering the Four Decisions in Microservices Architecture	Medium	2016	Grey	Blog post	Google	Excluded	Included	0	Included	https://medium.com/systems-architectures/walking-the-microservices-path-towards-loose-coupling-
~~Philippe De Ryck~~	~~GOTO 2019 • Common API Security Pitfalls • Philippe De Ryck~~	~~GOTO Conferences~~	~~2019~~	~~Grey~~	~~Video~~	~~Google~~	Excluded	Excluded	1	Excluded	https://youtu.be/Ss1tZjooo9I
~~K&C Team~~	~~KUBERNETES AT THE FOREFRONT OF SECURE MICROSERVICES FUTURE~~	~~K&C~~	~~2020~~	~~Grey~~	~~Blog post~~	~~Google~~	Excluded	Excluded	1	Excluded	https://kruschecompany.com/kubernetes-at-the-forefront-of-secure-microservices-future/
~~Ranga Rajagopalan~~	~~Application Services 101 | Dodging Microservices Pitfalls~~	~~AVI Networks~~	~~2016~~	~~Grey~~	~~Blog post~~	~~Google~~	Excluded	Excluded	1	Excluded	https://blog.avinetworks.com/application-services-101
Robert Lemos	App security in the microservices age: 4 best practices	TechBeacon	2019	Grey	Blog post	Google	Included	Included	1	Included	https://techbeacon.com/app-dev-testing/app-security-microservices-age-4-best-practices
~~Ranny Nachmias~~	~~Cloud Native Security Best Practices~~	~~Container Journal~~	~~2019~~	~~Grey~~	~~Blog post~~	~~Google~~	Excluded	Included	0	Excluded	https://containerjournal.com/topics/container-security/cloud-native-security-best-practices/
~~RALPH JANKE~~	~~SECURITY CONSIDERATION FOR MICROSERVICES USING CONTAINER TECHNOLOGY~~	~~Sector~~	~~2017~~	~~Grey~~	~~Video~~	~~Google~~	Excluded	Excluded	1	Excluded	https://sector.ca/sessions/security-consideration-for-microservices-using-container-technology/
ZACH GARDNER	Security in the Microservices Paradigm	KEYHOLE Software	2017	Grey	Blog post	Google	Duplicate	Duplicate	1	Excluded	https://keyholesoftware.com/2017/03/13/security-in-the-microservices-paradigm/
~~Cameron Gain~~	~~Microservices Security: Probably Not What You Think It Is~~	~~TheNewStack~~	~~2018~~	~~Grey~~	~~Blog post~~	~~Google~~	Excluded	Excluded	1	Excluded	https://thenewstack.io/microservices-security-probably-not-what-you-think-it-is/

Tom Smith	How Do You Secure Microservices?	Dzone	2017	Grey	Blog post	Google	Included	Included	1	Included	https://dzone.com/articles/how-do-you-secure-microservices
~~Umberto Azadi ; Francesca Arcelli~~	~~Architectural Smells Detected by Tools: a Catalogue Proposal~~	~~International Conference on Technical Debt~~	~~2019~~	~~White~~	~~Conference~~	~~IEEE Xplore~~	Excluded	Excluded	1	Excluded	https://ieeexplore.ieee.org/abstract/document/8785058
~~Katja Tuma, Danial Hosseini, Kyriakos~~	~~Inspection guidelines to identify security design flaws~~	~~European Conference on Software Architecture~~	~~2019~~	~~White~~	~~Conference~~	~~ACM Digital Library~~	Excluded	Excluded	1	Excluded	https://dl.acm.org/doi/abs/10.1145/3344948.3344995
~~J. Bogner, T. Boceck, M. Popp, D. Tschechlov,~~	~~Towards a Collaborative Repository for the Documentation of Service-Based Antipatterns and Bad Smells~~	~~International Conference on Software Architecture~~	~~2019~~	~~White~~	~~Conference~~	~~IEEE Xplore~~	Excluded	Excluded	1	Excluded	https://ieeexplore.ieee.org/abstract/document/8712355
~~Andrei Furda Colin Fidge Alistair Barros Olaf~~	~~Reengineering Data-Centric Information Systems for the Cloud — A Method and Architectural Patterns Promoting Multitenancy~~	~~Software Architecture for Big Data and the~~	~~2017~~	~~White~~	~~Book chapter~~	~~Scopus~~	Excluded	Excluded	1	Excluded	http://www.sciencedirect.com/science/article/pii/B9780128054673000132
~~Ramaswamy Chandramouli~~	~~Security Strategies for Microservices-based Application Systems~~	~~Special Publication (NIST SP)~~	~~2019~~	~~Grey~~	~~Whitepaper~~	~~Google Scholar~~	Excluded	Excluded	1	Excluded	https://www.nist.gov/publications/security-strategies-microservices-based-application-systems
A. Nehme, V. Jesus, K. Mahbub and A. Abdallah	Securing Microservices	IT Professional	2019	White	Journal	IEEE Xplore	Included	Included	1	Included	https://ieeexplore.ieee.org/abstract/document/8657392
T. Yarygina and A. H. Bagge	Overcoming Security Challenges in Microservice Architectures	Symposium on Service-Oriented System	2018	White	Conference	IEEE Xplore	Included	Included	1	Included	https://ieeexplore.ieee.org/abstract/document/8359144
~~Fangchao Tian ; Peng Liang ; Muhammad~~	~~How Developers Discuss Architecture Smells? An Exploratory Study on Stack Overflow~~	~~International Conference on Software Architecture~~	~~2019~~	~~White~~	~~Conference~~	~~IEEE Xplore~~	Excluded	Excluded	1	Excluded	https://ieeexplore.ieee.org/abstract/document/8703915

A R Manu ; Jitendra Kumar Patel ; Shakil Akhtar ;	Docker container security via heuristics based multilateral security conceptual and pragmatic study	International Conference on Circuit, Power and	2016	White	Conference	IEEE Xplore	Excluded	Excluded	1	Excluded	https://ieeexplore.ieee.org/abstract/document/7530217
Davide Taibi, Nabil El Ioini, Claus Pahl, Jan Raphael	Serverless Cloud Computing (Function as a Service) Patterns: A Multivocal Literature Review	International conference on Cloud Computing	2020	White	Conference	Scholar	Excluded	Excluded	1	Excluded	https://www.researchgate.net/profile/Davide_Taibi/publication/340121613_Patterns_for_Serverless_Funct
GiulianoCasaleCristinaChesta PeterDousseElisabettaDi	Current and Future Challenges of Software Engineering for Services and Applications	Procedia Computer Science	2016	White	Journal	Scopus	Excluded	Excluded	1	Excluded	https://www.sciencedirect.com/science/article/pii/S1877050916320944?via%3Dihub
Seyed Yahya Nikouei, Yu Chen, Alexander	I-SAFE: instant suspicious activity identification at the edge using fuzzy decision making	ACM/IEEE Symposium on Edge Computing	2019	White	Conference	ACM Digital Library	Excluded	Excluded	1	Excluded	https://dl.acm.org/doi/abs/10.1145/3318216.3363307
Sahil Suneja, Ali Kanso, and Canturk Isci	Can Container Fusion Be Securely Achieved?	International Workshop on Container Technologies	2019	White	Conference	ACM Digital Library	Excluded	Excluded	1	Excluded	https://dl.acm.org/doi/abs/10.1145/3366615.3368356
Christian Esposito ; Aniello Castiglione ;	Challenges in Delivering Software in the Cloud as Microservices	IEEE Cloud Computing	2016	White	Journal	IEEE Xplore	Included	Included	1	Included	https://ieeexplore.ieee.org/abstract/document/7742281
Mohammad Khodaei, Hamid Noroozi, and	Scaling pseudonymous authentication for large mobile systems	Conference on Security and Privacy in Wireless	2019	White	Conference	ACM Digital Library	Excluded	Excluded	1	Excluded	https://dl.acm.org/doi/abs/10.1145/3317549.3323410
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Literature Analysis

ID	Smell	Why	Refactoring	Why	Francisco	Jacopo	Agreement
1	**Non-proper access control**	The overwhelming majority of	**Use OAuth 2.0**	OAuth/OAuth2 is practically	X	X	1
	No layered security	Assuming that a firewall on	**Use defense-in-depth**	"Defense in depth" is defined	X	X	1
	Own crypto code	Don't write your own crypto	**Use already validated**	the open source tools already	X	X	1
	Publicly accessible	Get your containers out of the	**Use firewall for the API**	By using this technique you	X	X	1
2	**Publicly accessible**		**Secure APIs**	Your APIs are the gateway	X	X	1
	Insecure infrastructure	With Infrastructure-as-Code,	**Restrict commits**	Important to restrict who can	X	X	1
	Insecure infrastructure	With Infrastructure-as-Code,	**Review code merges**	Important to review code	X	X	1
	Decentralized Authentication		**Use API Gateway**	API Gateway is the most	X	X	1
	Centralized authorization		**Use a token-based approach**	We have decentralized	X	X	1
	Centralized authorization		**Use CQRS**	Command and query	X	X	1
	Non-standard identity		**Use JSON Web Tokens (JWT)**	JWT allows us to pass identity		X	0
	Hardcoded secrets	Bad ideas: Hardcoding	**Encrypt secrets at rest**			X	0
3	**Decentralized Authentication**		**Use API Gateway**	the API Gateway is the best	X	X	1
	Own crypto code	minimize the amount of code	**Use already validated**	maximize the amount of code	X	X	1
4	**Centralized authorization**	monolithic applications. For the	**Use a token-based approach**		X	X	1
	Non-standard Authorization	Most applications within a	**Use OAuth 2.0**	recommend using OAuth and	X	X	1
	No layered security	A standard firewall on the	**Use defense-in-depth**	microservices calls for a more	X	X	1
	Publicly accessible	While it is possible, in theory,	**Use firewall for the API**	By placing the API gateway	X	X	1
5	**Publicly accessible**		**Use firewall for the API**	API Gateway pattern that	X	X	1
	Non-scalable security		**DevSecOps**	DevSecOps approach that	X	X	1
	Non-scalable security		**Continuous Security Testing**	Automating security tests for	X	X	1
	Non-standard Authorization		**Use OAuth 2.0**	Authorized access to	X	X	1
	Non-encrypting sensitive		**Encrypt data at rest**	try and test encryption	X		0
	No layered security		**Use defense-in-depth**	Securing infrastructure-level	X	X	1
6	**No layered security**	Rather than assuming a	**Use defense-in-depth**	This adds redundancy to your	X	X	1
	No layered security	Microservices are still subject	**Use defense-in-depth**	You can take a major step	X	X	1
	Non-secure communication	anyone who can set up a	**Use Transport Layer**	It's better to be proactive and	X	X	1

	Non-encrypting sensitive	Whether that's your database	**Encrypt data at rest**	Encrypting data at rest is a	X	X	1
	unnecessary privileges to	Another common pitfall when	**Least privilege principle**	By limiting what services can	X		0
	Non-proactive security	Most of the time, we don't "just	**Use attack mitigation**	An Application Security	X	X	1
8	**Non-standard Authorization**	You need to ensure that the	**Use OAuth 2.0**	OAuth2 is a token-based	X	X	1
	Non-secure communication		**Use transport Layer Security**	your microservices should	X	X	1
	Decentralized security policy	The individual servers, service	**Use API Gateway**	Instead, use a services	X	X	1
	unnecessary privileges to	Least privilege is the concept	**Least privilege principle**	The public zone contains the	X	X	1
	unnecessary privileges to		**Lock down unneded network**	Limit the attack surface of your	X		0
#	**Non-standard authentication**	Authentication to microservices	**Use OpenID Connect**	Access to such APIs should	X	X	1
	Decentralized Authentication	Unlike a monolithic application	**Use API Gateway**	Makes sense to provide a		X	0
	Giant API Gateway	To prevent the gateway from	**Use Backend for Frontend**	In BFF, each client type is	X	X	1
	Non-secure communication	Secure communication	**Transport Layer Security**	Communication between an	X	X	1
	Non-proactive security	Though it is impossible to	**Use attack mitigation**	A run-time prevention strategy	X	X	1
#	**No layered security**		**Use defense-in-depth**	A technique through which	X	X	1
	Decentralized Authentication		**Use API Gateway**	Add an extra element to	X	X	1
	Non-standard Authorization	Client details and permissions	**Use OAuth 2.0**	Tokens need to be encrypted	X	X	1
	Non-secure communication	Applications often face traffic	**Transport Layer Security**	With mutual SSL, the data	X	X	1
#	**Non-secure communication**	Those in process calls are now	**Use Transport Layer**	HTTPS is a good default	X	X	1
	Non-standard Authorization	Confused Deputy Problem!	**Use OAuth 2.0**	Use OAuth to manage	X	X	1
	Non-encrypting sensitive		**Encrypt data at rest**	Identify the most critical	X	X	1
#	**Non-secure communication**		**Use Transport Layer**	Encrypt all traffic to your end-	X	X	1
	unnecessary privileges to		**Least privilege principle**	Each component in your	X	X	1
	Non-proactive security	Never assume that your	**Use attack mitigation**	Rate limit and throttle your	X	X	1
	No layered security	You need to design a secure	**Use defense-in-depth**	WAF + API Gateway + TLS +	X	X	1
	Hardcoded secrets	Do not store private keys &	**Encrypt secrets at rest**	Exposure of you private key	X	X	1
	Non-encrypting sensitive		**Encrypt data at rest**	You need to encrypt or Hash	X	X	1
#	**Publicly accessible**	You have multiple endpoints	**Use API Gateway**	You selectively pick a set of	X	X	1
	Trust the Network	Today we consider it an	**Zero Trust Network**	You need to go for a zero-trust	X	X	1
	Non-secure communication		**Transport Layer Security**	Encrypt all traffic to your	X	X	1
#	**No layered security**	Securing the perimeter is not	**Use defense-in-depth**	Using an extra firewall or	X	X	1

	Non-encrypting sensitive		**Encrypt data at rest**	Sensitive data should be	X	X	1
	Decentralized Authentication		**Use API Gateway**	It is common to have	X		0
	Centralized authorization	With a monolithic application, it	**Decentralize authorization**	When working with	X		0
	Own crypto code		**Use already validated**	Use known data encryption	X	X	1
	Hardcoded secrets	Secrets should never be	**Encrypt secrets at rest**	Do not store your credentials	X	X	1
	Non-scalable security		**DevSecOps**	Repeatable automated	X	X	1
	Trust the Network	It is inherently unsafe to	**Zero Trust Network**		X	X	1
	Non-standard Authorization	You must establish and	**Use OAuth 2.0**	OAuth provides an open	X	X	1
	Non-standard authentication	You must establish and	**Use OpenID Connect**	OIDC provides an identity layer	X	X	1
	Non-standard identity	Identity propagation is another	**Use JSON Web Tokens (JWT)**	JWTs can be used to carry	X	X	1
#	**Non-secure communication**	When we are working with	**Use JSON Web Tokens (JWT)**	There are many ways to do	X	X	1
	Decentralised authentication		**Centralise authentication**	Single Sign-On	X		0
	Non-secure communication		**Use Transport Layer**	It enables the Secure Socket	X	X	1
	Publicly accessible	Imagine that our application,	**Use API Gateway**	If you imagine microservices as	X	X	1
#	**Non-standard Authorization**		**Use OAuth 2.0**	Setting proper access controls	X	X	1
	Non-standard identity		**Use JSON Web Tokens (JWT)**	Access controls can be set to	X	X	1
	Publicly accessible		**Use API Gateway**	Use of API gateway and	X	X	1
	Hardcoded secrets	Never store sensitive keys and	**Encrypt secrets at rest**		X	X	1
	Using experimental solutions	Never use newer experimental	**Use already validated**		X	X	1
#	**Decentralized Authentication**	The microservices architecture	**Use API Gateway**	In order to centralize the	X	X	1
	Non-secure communication		**Use Transport Layer**	All HTTP connections should	X	X	1
	Non-encrypting sensitive	Beyond the encrypted data in	**Encrypt data at rest**	All sensitive data should be	X	X	1
	Own crypto code		**Use already validated**	Using existing data encryption	X	X	1
	Non-proactive security	Nowadays, one of the most	**Use attack mitigation**	In order to prevent this issue	X	X	1
	Non-proactive security	Microservices authentication	**Use attack mitigation**	To avoid any vulnerability,	X	X	1
	unnecessary privileges to		**Least privilege principle**	Using of trusted base	X	X	1
	~~**Not monitoring services**~~		~~**Monitor everything that is**~~	~~You should monitor everything~~		X	0
#	**unnecessary privileges to**		**Least privilege principle**	Develop an understanding of	X	X	1
	Non-scalable security		**DevSecOps**	Where possible, use	X	X	1
	Non-secure communication		**Use Transport Layer**	When using external access	X	X	1

#	**Non-secure communication**		**Use transport Layer Security**	Select a security solution that	X	X	1
	Non-scalable security		**DevSecOps**	Deliver a security posture that	X	X	1
#	**No layered security**		**Use defense-in-depth**	Defense-in-depth is a strategy	X	X	1
	Decentralized Authentication	In a microservices-based	**Use API Gateway**	An API gateway should	X	X	1
	Publicly accessible		**Use firewall for the API**	You can add a layer of	X	X	1
	Non-secure communication		**Use transport Layer Security**	Microservices often need to	X	X	1
	unnecessary privileges to		**Least privilege principle**	Also, closely guard API	X	X	1
	Non-scalable security	Microservices security best	**DevSecOps**	DevSecOps, dictates that	X	X	1
#	**Publicly accessible**		**Use API Gateway**	Any organization that is	X	X	1
	Non-secure communication		**Use transport Layer Security**	It almost goes without saying	X	X	1
	Trust the Network		**Zero Trust Network**	In addition, the internal	X	X	1
	unnecessary privileges to		**Least privilege principle**	Employ a principle of least-	X	X	1
	Non-proactive security		**Use attack mitigation**	rate limiting can limit the	X	X	1
	Non-standard Authorization		**Use OAuth 2.0**	API clients should be	X	X	1
#	**Trust the Network**	Some do work around this by	**Zero Trust Network**	With zero-trust networking	X	X	1
	Non-standard identity	Nothing is shared among	**Use JSON Web Tokens (JWT)**	Using a JSON Web Token	X	X	1
	Non-standard Authorization		**Use OAuth 2.0**	In these kinds of delegated	X	X	1
	Non-secure communication	When you transfer data from	**Transport Layer Security**	The most common way to	X	X	1
	Non-encrypting sensitive	Along with the data in transit,	**Encrypt data at rest**	To protect a system for	X	X	1
	No layered security		**Use defense-in-depth**	Defenses against such attacks	X	X	1
	Decentralized security policy		**Use API Gateway**	The API gateway centrally	X	X	1
	Non-secure communication		**Use JSON Web Tokens (JWT)**	JSON Web Token is the third	X	X	1
	Publicly accessible	In a typical microservices	**Use API Gateway**	In most cases, microservices	X	X	1
#	**Non-secure communication**		**Use transport Layer Security**	One way to limit the	X	X	1
	Centralized authorization		**Use a token-based approach**	Tokens are JSON-based, and	X	X	1
	Non-standard Authorization		**Use OAuth 2.0**	OAuth 2.0 is the preferred	X	X	1
	Non-standard authentication		**Use OpenID Connect**	OpenID Connect is an	X	X	1
	Non-secure communication		**Use JSON Web Tokens (JWT)**	JSON Web Token (JWT) is a	X	X	1
	Trusting your own		**Zero Trust Network**	a singular approach could be		X	0
	Decentralized security policy		**Use API Gateway**	Gateways do the same, but	X	X	1

#	**Decentralized security policy**	Each microservice can be	**Use API Gateway**	This is where the API Gateway	X	X	1
	unnecessary privileges to	A major problem with this	**Least privilege principle**	This approach is too	X		0
	Non-proactive security		**Use attack mitigation**	Rate-limiting prevents calling of	X	X	1
	Non-standard Authorization	It is important to have user-	**Use OAuth 2.0**	You can use protocols such as	X	X	1
	Non-standard authentication	It is important to have user-	**Use OpenID Connect**	You can use protocols such as	X	X	1
#	**Non-standard authentication**	Microservices don't lend	**Use OpenID Connect**	By using OAuth with OpenID	X	X	1
	Non-standard Authorization	Microservices don't lend	**Use OAuth 2.0**	By using OAuth with OpenID	X	X	1
#	**Non-proactive security**		**Use attack mitigation**	To ensure API security, a WAF	X	X	1
	Non-scalable security		**DevSecOps**	The operational aspects of	X	X	1
	Non-secure communication		**Use transport Layer Security**	Your organization should	X	X	1
	Non-encrypting sensitive	Data security becomes even	**Use a data-centric audit and**	A DCAP solution helps you	X	X	1
#	**No layered security**	With the third-party APIs used	**Use defense-in-depth**	API's should be monitored for	X	X	1
	Unauthenticated API		**Use Authentication**	During the design time, the		X	0
#	**Non-scalable security**		**Continuous Security Testing**	Automating security testing in	X	X	1
	Unauthenticated API		**Use Authentication**	Access is another critical factor	X	X	1
	No layered security	Protecting your microservices	**Use defense-in-depth**	The defense in depth	X	X	1
	Non-scalable security	You need to Integrate	**DevSecOps**	Automation is the key to	X	X	1
#	**Decentralized authentication**		**Use API Gateway**	Services require authentication	X	X	1
	Centralized authorization	Approach 1: Global	**Decentralize authorization**	This approach is likely the best	X		0
	Decentralized authentication	Approach 4: Service	**Use API Gateway**		X		0
	Non-secure communication	If any service within your	**Transport Layer Security**	You need to have strong	X	X	1
#	**Non-proactive security**	Ensuring that your applications	**Use attack mitigation**	Setting up a firewall	X	X	1
	Non-secure communication		**Use transport Layer Security**	Traffic between your	X	X	1
	Hardcoded secrets	Embedding secrets into your	**Use third-party**	One strategy is to use third-	X	X	1
	Non-scalable security	When you are dealing with	**Continuous Security Testing**	This requires scanning the	X	X	1
#	**Non-proactive security**		**Use attack mitigation**	We also recommend enabling	X	X	1
	Decentralized authentication		**Use API Gateway**	It may be possible for your	X	X	1
	Non-proactive security		**Use attack mitigation**	Ensure you have reasonable	X	X	1
	Not knowing your system	Application layer attacks focus	**Identify critical services**	First and foremost it is critical	X	X	1
#	**Trust the Network**	A network, private or public, is	**Zero Trust Network**	Zero Trust = Authentication +	X	X	1

	Non-secure communication	Assuming resources are	**Use transport Layer Security**	Be it user to service, service to	X	X	1
	Not knowing your system		**Identify critical services**	All critical data stores,		X	0
#	**Hardcoded secrets**	Don't put secrets in native	**Encrypt secrets at rest**	An example of this is Proof-	X	X	1
	Trusting your own		**Zero Trust Network**	Treat components of your	X	X	1
	Non-standard Authorization	How can I let an app access	**Use OAuth 2.0**	OAuth acts as a buffer	X	X	1
#	**Decentralized authentication**		**Use API Gateway**	Even with IP whitelisting in	X	X	1
	Non-standard Authorization		**Use OAuth 2.0**	The most common is OAuth	X	X	1
	Unauthorized API requests	authentication alone is not	**Use authorization**	There various ways to check	X	X	1
	Non-proactive security		**Use attack mitigation**	Use rate-limiting API calls to	X	X	1
	Non-encrypting sensitive		**Encrypt data at rest**	Encryption in transit is great,	X	X	1
	~~**Not monitoring services**~~		~~**Monitor everything that is**~~	~~alert and monitoring are key to~~	X		0
	Non-secure communication	Protecting the backend	**Transport Layer Security**	When it comes to securing	X	X	1
#	**Decentralized security policy**		**Use API Gateway**	API Gateways are a natural	X	X	1
	Non-standard Authorization	When we talk about	**Use OAuth 2.0**	Use OAuth 2.0 to manage	X	X	1
	Non-standard authentication		**Use OpenID Connect**	Use OIDC to manage	X	X	1
#	**Centralized authorization**	In MSA, we can replace the	**Use a token-based approach**	The client talks to an identity	X	X	1
#	**Non-secure communication**		**Use transport Layer Security**	Developers should strive to	X	X	1
	Non-proactive security	The technology stack and the	**Keep third-party components**	The most popular platforms for	X	X	1
	Own crypto code	Developers should not try to	**Use already validated**		X	X	1
	Non-scalable security	Developers cannot afford to	**Continuous Security Testing**	Security also has to move as	X	X	1
#	**Decentralized Authentication**		**Use API Gateway**	API gateways are the most	X	X	1
#	**Non-standard Authorization**	Microservices should only be	**Use OAuth 2.0**	OAuth (currently in version 2.0)	X	X	1
	Centralized authorization	Verifying the access token at	**Use a token-based approach**	Having access control enabled	X	X	1
	Decentralized Authentication	Microservices require a central	**Use API Gateway**	A common model for	X	X	1
	Non-scalable security		**Continuous Security Testing**	Automated testing and	X	X	1
	Non-proactive security		**Use attack mitigation**	Any request from the outside	X	X	1
#	**Non-secure communication**	Classic attacks on the network	**Use transport Layer Security**	Use of standard and verified	X	X	1
	Non-secure communication		**Transport Layer Security**	Although there are currently	X	X	1
	No layered security	Until recently perimeter	**Use defense-in-depth**	We should rather assume that	X	X	1
	Trusting your own	We assume an adversary can	**Zero Trust Network**		X	X	1

	Centralized authorization	Microservices should be aware	**Use a token-based approach**	Token-based authentication is	X	X	1
#	**Trusting your own**	Trustworthiness is also an	**Zero Trust Network**		X	X	1
	Non-secure communication	In the absence of a	**Use transport Layer Security**		X	X	1
#	**Non-scalable security**	Any vulnerability should be	**Continuous Security Testing**	A proper secure development	X	X	1
	Non-secure communication	Securing service-to-service	**Use JSON Web Tokens (JWT)**	JWT (JSON Web Token)	X	X	1
	Non-secure communication	Securing service-to-service	**Transport Layer Security**	Mutual authentication	X	X	1
	Decentralized Authentication		**Use API Gateway**	With the API gateway pattern	X	X	1
	Non-standard Authorization		**Use OAuth 2.0**	The most common way of	X	X	1
	Centralized authorization	An authorization check	**Use token-based approach**	XACML is the de-facto		X	0
#	**Non-secure communication**	HTTP transfers data in plain	**Use transport Layer Security**	We definitely don't want to	X	X	1
	Non-standard Authorization	Providing authentication and	**Use OAuth 2.0**	OAuth is an open	X	X	1
#	**Non-proactive security**		**Use attack mitigation**	A web application firewall	X	X	1
	Non-secure communication		**Use transport Layer Security**	TLS or Transport Layer	X	X	1
	Non-encrypting sensitive	Assuming our system had	**Encrypt data at rest**	One of the many benefits	X	X	1
	unnecessary privileges to		**Least privilege principle**	There is a security principle	X	X	1
	Centralized authorization		**Use JSON Web Tokens (JWT)**	A JSON Web Token (JWT) is a	X	X	1
	Non-proactive security		**Keep third-party components**	One important element of	X	X	1
	Decentralized Authentication		**Use API Gateway**	In addition to a WAF, an API	X	X	1
#	**Non-standard Authorization**	In a microservice-based	**Use OAuth 2.0**	One possible solution for this	X	X	1
	Non-secure communication		**Transport Layer Security**	The communication between	X	X	1
	No layered security		**Use defense-in-depth**	Firewalls can be used to	X	X	1
#	**Trust the Network**	Our first option could be to just	**Zero Trust Network**		X	X	1
	Centralized authorization	There is a type of vulnerability	**Use a token-based approach**		X	X	1
	Non-encrypting sensitive	Many of the high-profile	**Encrypt data at rest**	For encryption at rest, unless	X	X	1
	Own crypto code	The easiest way you can mess	**Use already validated**	Whatever programming	X	X	1
	No layered security		**Use defense-in-depth**	As I've mentioned earlier, I	X	X	1
#	**Publicly accessible**	"Before you had to secure one	**Use firewall for the API**	To tackle this challenge, it	X	X	1
#	**Non-standard Authorization**	In a monolithic web	**Use OAuth 2.0**	The OAuth2 authorization	X	X	1
	Centralized authorization	When a service wants to get	**Use a token-based approach**	A token is usually built as a	X	X	1
	Centralized authorization		**Use JSON Web Tokens (JWT)**	OAuth2 uses the JWT	X		0

	Non-proactive security	When you're exposing HTTP	**Use attack mitigation**	Web Application Firewalls	X	X	1
	Non-proactive security		**Use attack mitigation**	Rate limiting consists of	X	X	1
#	**No layered security**	- Are you just protecting your	**Use defense-in-depth**		X	X	1
	Non-secure communication	- How easily could someone	**Use transport Layer Security**		X	X	1
	Trusting your own	- Do your services trust each	**Zero Trust Network**		X	X	1
	Non-standard Authorization	-Can your services request any	**Use OAuth 2.0**		X	X	1
	Non-standard authentication	- I have a list of cracked	**Use Authentication**		X	X	1
	unnecessary privileges to	- Do you share a single	**Least privilege principle**		X	X	1
#	**Centralized authorization**	The most important aspect of	**Use a token-based approach**	An access key, or access	X	X	1
#	**Non-secure communication**	The communication channel	**Use transport Layer Security**	A secure channel should be	X	X	1
	Unauthenticated API	A weak set of APIs exposes	**Use Authentication**	Use keys or security tokens or	X	X	1
	Decentralised authentication		**Single Sign-on**			X	0
	Centralized authorization		**Use a token-based approach**	REST web services can use	X	X	1
#	**Decentralized security policy**	A further requirement is to	**Use API Gateway**	We approach this by designing	X	X	1
	Non-standard Authorization		**Use OAuth 2.0**	Open Authorization 2 (OAuth	X	X	1
	Non-standard authentication		**Use OpenID Connect**	OpenID Connect, built on top	X	X	1
	Centralized authorization	On the other hand, we have	**Use a token-based approach**	The key point to prevent this is	X	X	1
#	**Non-standard Authorization**	Many security analysts do not	**Use OAuth 2.0**	Using libraries and functions	X	X	1
	No layered security	You need to identify your most	**Use defense-in-depth**	Microservices makes it easier	X	X	1
	Own crypto code	It is advised that when it	**Use already validated**	you've got people skilled	X	X	1
	Publicly accessible	Get your containers out of the	**Use API Gateway**	By using this technique you	X	X	1
	Non-scalable security		**Continuous Security Testing**	The best solution for	X	X	1
#	**Non-proactive security**	Third-party dependencies	**Keep third-party components**	You can use a scanning	X	X	1
	Non-secure communication		**Use transport Layer Security**	You should use HTTPS	X	X	1
	Non-standard Authorization		**Use OAuth 2.0**	OAuth 2.0 has provided	X	X	1
	Hardcoded secrets	When you develop	**Encrypt secrets at rest**	The first step to being more	X	X	1
	Non-scalable security	Dependency and container	**DevSecOps**	DevSecOps is the term many	X	X	1
	Non-proactive security	If someone tries to attack your	**Use attack mitigation**	You can implement rate-	X	X	1
	Non-proactive security	The idea behind time-based	**Use attack mitigation**	Use multi-factor authentication	X	X	1
#	**Publicly accessible**		**Use API Gateway**	Pros of API Gateway: High	X	X	1

	Giant API Gateway	The Mobile client's API	**Use Backend for Frontend**	In a highly secured scenario	X	X	1
#	**Trust the Network**	Over time, trust-the-network	**Zero Trust Network**	With zero-trust networking	X	X	1
	Non-standard identity	The challenge is to build trust	**Use JSON Web Tokens (JWT)**	Using a JSON Web Token	X	X	1
#	**Publicly accessible**	The first step is to isolate and	**Use API Gateway**	For instance, only the top-level	X	X	1
	Non-secure communication	Lack of transparency of cloud	**Transport Layer Security**	One of the standard ways to	X	X	1
	Centralized authorization	top-level services need to	**Use a token-based approach**	Standard techniques such as	X	X	1
#	**Decentralised authentication**	It is inconvenient that	**Centralise authentication**	Among the many possible	X	X	1
	Non-secure communication	In Microservices, services must	**Use transport Layer Security**	It is advisable to use HTTPS	X	X	1
	Non-encrypting sensitive	Many breaches take place in	**encrypt data at rest**	its necessary to assure that	X	X	1
	No layered security	Microservices acts in layer or	**use defense-in-depth**	defense in depth is probably a	X	X	1
						IRR	91,90

Classification

	Integrity				Confidentiality			Authenticity		
	Own crypto code	Non-encryped data exposure	Hardcoded secrets	Non-secured service-to-service communication	Insufficient access control	Publicly accessible microservices	unnecessary privileges to microservices	Unauthenticated traffic	Centralized authorization	Multiple User Authentication
Paper Id	Use already validated encryption technologies	Encrypt all sensitive data at rest	Encrypt secrets at rest	Use mutual TLS	use OAuth 2.0	Add an API Gateway	follow the least privilege principle	use mutual TLS + use OpenID connect	use decentralized authorization	use single Sign-on
1	X				X	X				
2			X			X			X	X
3	X					X				X
4					X	X			X	
5		X			X	X				
6	X		X					X		
7		X		X			X	X		
8				X	X	X	X			
10				X				X		X
12				X	X					X
13		X		X	X					
15		X	X	X			X			
16				X		X				
17	X	X	X		X			X	X	X
18				X		X				X
19	X		X		X	X			X	
20	X	X		X			X			X
21				X			X			
22				X						
23				X		X	X			X
24				X	X	X	X			
25		X		X	X	X			X	X
26				X	X	X		X	X	
27					X	X	X	X		
28					X			X		

29		X		X						
30								X		
31								X		
32				X		X			X	X
33			X	X						
34							X			X
35				X			X			
36			X		X					
37		X		X	X			X		X
38					X	X		X		X
39									X	
40	X			X						
42						X				X
43					X	X			X	X
44				X					X	
45				X						
46				X	X	X			X	X
47				X	X					
48		X		X		X	X		X	X
49				X	X					
50	X	X							X	
51						X				
52					X				X	
53				X	X		X	X		
54									X	
55				X				X	X	X
56					X	X		X	X	X
58	X				X	X				
59			X	X	X					
60						X				
61									X	
62				X		X			X	
63		X		X						X
	9	12	8	32	25	25	12	14	19	20