Truong, Linh; Zhang, Liang

Resilience and Elasticity for Continuous Service-based Processes in Pandemic Ages

Published in:
IT Professional

DOI:
10.1109/MITP.2021.3098761

Published: 01/01/2021

Document Version
Peer-reviewed accepted author manuscript, also known as Final accepted manuscript or Post-print

Please cite the original version:
Truong, L., & Zhang, L. (2021). Resilience and Elasticity for Continuous Service-based Processes in Pandemic Ages. *IT Professional*, *23*(5), 31-37. https://doi.org/10.1109/MITP.2021.3098761

Resilience and Elasticity for Continuous Service-based Processes in Pandemic Ages

Hong-Linh Truong and Liang Zhang

August 13, 2021

Abstract

COVID-19 turns service-based business continuity into a hot issue, due to the survival of enterprises under long-tailed changes of business caused by various abnormal socio-economic events and disruptions. We analyze how current techniques enable small and medium enterprises (SMEs) to be resilient and elastic. From observations of service disruptions during COVID-19 and problems with current technologies for resilience and elasticity, we recommend addressing resilience and elasticity requirements through contextual service information and hybrid services coordination programming and serving.

1 Introduction

COVID-19 situations have forced enterprises to conduct business more dynamically. For business survival, multiple types of responses and impacts on underlying IT systems have been identified from different industries [1]. Besides novel IT solutions for fighting and mitigating COVID-19 (e.g., digital contact tracing and simulation models [2]), the need to reshape IT systems for handling businesses in today's and future's pandemic situations, such as reducing system risks, improving service resilience and recovering communication, is of paramount importance [1, 3]. In this direction, we look at how to improve business continuity in pandemics through elastic and resilient hybrid services coordination.

Two key enabling abilities for business survival in a pandemic age are *resilience* and *elasticity*:

- resilience: maintains business to meet a certain quality standard, even in case of service disruption or resource shortage due to emergent situations.
- elasticity: makes business responsive under varying amount of workloads and adapts the business by leveraging multiple types of resources in different ways.

Multiple types of resources, such as humans, IoT, and machine learning-based analytics services, can ease the implementation of resilience and elasticity. However, we face the following situations:

- *rich but inaccurate information*: the information is abundant , but with different quality, and lacks business semantic consensus. For example, information is updated frequently from partners, customers, and the government w.r.t. COVID-19 but the information is not ready for automated business processes.
- *human-in-the-loop as problems and opportunities*: knowledge and gig workers as part of business processes and in the enterprise supply chain, customers, and external stakeholders are strongly impacted so their availability is limited and rapidly changed. Given the unavailable functions in existing services and partners and the uncertainty of a long pandemic, human services and human-in-the-loop solutions become extremely important sources of data, coordinators, action triggers, and service offerings.
- *rapid service adaptation/integration tools without pandemic-pressured development support*: service integration can be rapidly implemented by using suitable frameworks such as configurable service connectors, serverless [4] and IFTTT [5] programming style. However, they have not been tested with local development constraints (time, cost, and data regulation) under pandemic pressures.

Unlike large enterprises which have self-contained service ecosystems, SMEs rely on external services and expertise. Therefore, business continuity for SMEs during the pandemic has a high risk.

2 Critical points of resilience and elasticity in SMEs

Let us focus on service disruptions due to strict rules/regulations for human activities and business operations that every enterprise must comply to. Like in COVID-19, to assure health safety, corresponding policies from governance bodies force SMEs to change their business. Such policies cause cascading change events propagated from (i) request/response from customers, (ii) situational information from the environments (newspapers, social networks, and IoT devices) and workers in the fields, and (iii) exchanges between partnering SMEs. Due to the characteristics of SMEs, knowledge and gig workers play various roles, such as common task executor, process coordinator, data collector, and situation analyzer. Dynamic policies for social distancing due to COVID-19 situations essentially increase the unavailability of resources for such roles.

Figure 1 presents key interactions centered around an SME's business. By analyzing interactions during a pandemic, we see that the critical point to continuous business is due to *dynamic cooperation/collaboration interactions* within and among SMEs. Information from customers and external sources (non-customer) are collected by different means, such as using automatic data collectors via social media and human-based feedback. IoT services and partnering SMEs can exchange data via messaging systems, whereas governance policies are handled mainly by humans. Thus, not all information is structured, accurate and interpretable by automated software. Both manual and automatic data analytics contribute to knowledge extracted from the information that will be used for *change* decisions for resilience/elasticity. An SME will have problems if there are no available automated facilities or human-based analytics, or if its SME partner is disrupted. When an SME caller makes changes in its business, requests and data exchanges will be sent to its SME callee. The callee will consider process monitoring, data exchanged, and other information to decide on changing the callee's business process and/or sending data to the caller. Connectors and coordinators between the caller and the callee can be technical APIs or humans, but again, many features are carried out by humans. Finally, an SME's decision-making requires different types of coordinators. Each implements a special type of coordination w.r.t. technical implementation (e.g., API and programming languages) and services (e.g., human services and software/AI services). The failure and unavailability of these coordinators are the root cause of disruptions. Overall, the business disruptions are related to business processes adaptation and human-based data analytics for making changes. Sidebar 1 highlights some observations within an SME and among SMEs in COVID-19.

For business continuity, we need to address long-tailed changes induced by dynamic, significant events such as those in Sidebar 1. To balance the cost and business continuity, such long-tailed changes require a *fast* implementation *after* the events to adapt business interaction and coordination. However, current service development techniques and business process management are not adequate to meet this requirement in pandemic times (see also Sidebar 2 on related work). We need to revisit the key steps to ensure business continuity for SMEs using resilience and elasticity strategies.

3 Hybrid services coordination programming and serving

What we suggest to practitioners and researchers is to employ hybrid services coordination programming and serving using context-specific service information and modern coordination techniques. With COVID-19, SMEs need multiple choices and types of service information for a given function to avoid catastrophic failures and to design recoverable failures. Furthermore, various coordination models involve humans and are changed, requiring us to deal with the resilience/elasticity using human services.

Requirements: Service discovery and interoperability allow select suitable services for replacing disrupted ones or adding new ones to meet changes and cost optimization. For SMEs, this process usually takes time due to the lack of tools and the amount of manual evaluation. We need to quickly decide and implement integration for many long-tailed changes due to the rapid adjustment of COVID-19 related policies. Then, we need an easy way to develop coordination functions of such context-specific services under resilience and elasticity conditions, especially for SMEs with a high degree of human-based services. Since coordination models are *"programs"*, we should have techniques to enable various forms of coordination "programs" based on human teams, AI, or traditional workflows to be deployed, replaced, and changed in pandemic situations, reflecting the ability of diversity and hybridity of SMEs. Finally, we need to address how we can enable such programs under "dynamic serving models" based on business and pandemic context for SMEs.

Limitations of current approaches: Elasticity and resilience strategies rely on accurate, context-specific service information, which is based on the availability of registries, catalogs, and well-defined service descriptions. However, most service description models with different types of context information are targeted at mainstream scenarios, not pandemic situations. Furthermore, there is a lack of tools to check interoperability and compatibility in an SME context. For example, to find a service that can deliver food, not only we make sure technical interfaces can be easily integrated (compatible problems [12]) and the quality of the service met availability, privacy, and cost constraints (QoS service selection [13]), but we also want to know if the service can operate in a district of COVID-19 self-isolating customers (contextual situations) and is complied with social distancing rules (for safety reason). All these contextual and safety factors will affect the business processes but cannot be modeled in advance during the pandemic.

Given available services, common solutions to speed up the service integration using drag and drop programming coordination functions of event-trigger-action are not very strong, but that is what SMEs need, such as features demonstrated by IFTTT or Zapier [14]. Another crucial issue is to support coordinating external services using humans as a coordination-as-a-function to deal with changing situations and emerging services/products. For example, a restaurant and a delivery service need to exchange the information w.r.t. goods and safety due to COVID-19, a software connector and a human are employed to collect data, but another person can coordinate the business process. However, rigorous (cross-enterprise) workflows with human tasks cannot be easily applied to SMEs. The concept of "serving" for coordination models is not well developed. For example, a coordination model is deployed

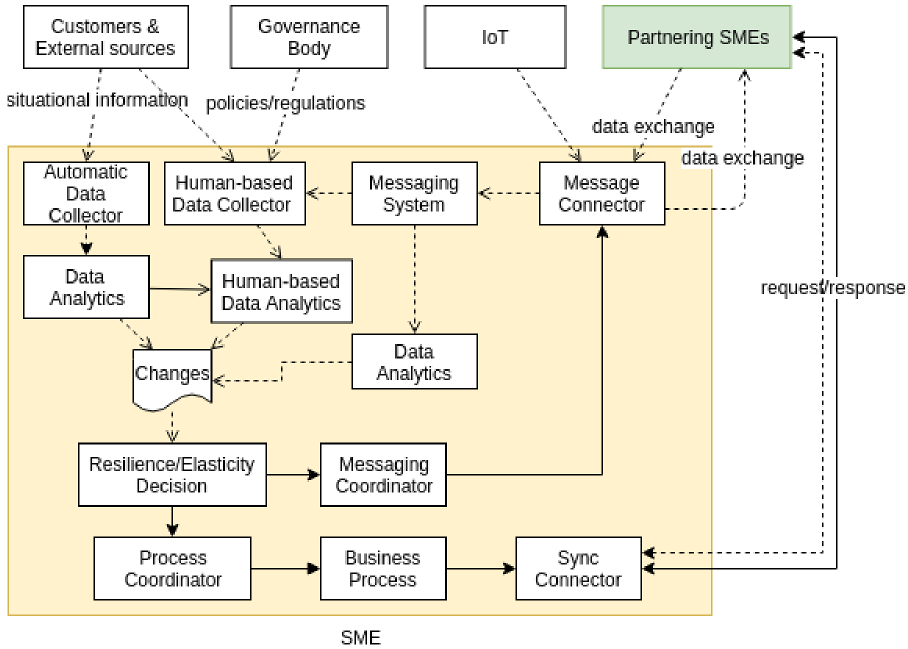

Figure 1: Coordination flows within an SME and between an SME and external parties

Sidebar 1: Examples of service disruptions and problems in current technologies observed in COVID-19

Resilience problems due to recoverable failures: *humans cannot be added for coordination*: in a business process, a reservation is approved automatically or by human at the final step. However, due to the dynamic change of policies, a step in the middle of the process must be checked by humans.
Resilience problems due to resource unavailability *failures of resources for analytics, coordination and task executors*: due to childcare closure or sickness, human operators are not available. Thus, various tasks in an SME cannot be done but the SME is not able to utilize external resources.
Elasticity problems in business processes: *quickly resource changes in processes*: Due to COVID-19, a business can change sick leave policies in all processes with human operators or the government changes shops opening policies quickly. Thus, several business processes must be reconfigured elastically, but it is not easily carried out quickly.
Elasticity problems for demands: *unexpected increasing service demands*: burst demands of various services for basic needs (e.g., individual tutoring due to the home learning for schoolchildren) cannot be scaled due to the lack of elasticity implementation.
Elasticity problems due to external services and internal coordination: *implementing social distancing*: retail shops use various IoT devices and business processes to analyze customers. Due to the social distancing rule, new services must be integrated and processes must be modified to accept new warnings that trigger staff actions or messages for customers in a shop. However, the retail shop systems fail to leverage such advanced services.
Resilience and elasticity problems due to the lack of service discovery: *new products offered but cannot be discovered*: SMEs adapt their business and offer new products but such products cannot be discovered due to the lack of service discovery.
Resilience and elasticity problems due to structural mismatch: *unused resources due to mismatching:* hotels are closed due to no tourists, but offer rooms for local people to use in their business to do remote work. New products are offered but the needs to bridge mismatched business and emerging requirements are not fulfilled.
Resilience problems to due partner coordination: *coordination disruption:* one business process is canceled in one SME (e.g., no more guest accepted into a festival event due to a large number of participants) but the other process is still working in the partnering SME (e.g. hotel guest booking).
Resilience and elasticity problems due to in-chain partners: *searching and switching new partners:* An existing partner is not operable due to COVID-19, thus a new partner must be found. This cannot be done easily and fast. For example, as widely reported, farms cannot sell vegetables to food-service companies, which process and package goods and deliver to (widely) customers. Farms need to find new ways to sell and deliver vegetables to local customers, leading to changes in several services in the chain.

Sidebar 2: Relevant research work

There are a huge number of papers discussing service adaptation, elasticity, and resilience frameworks [6]. They focused on technical frameworks without links back to the business services resilience/elasticity in pandemics. The workflow reconfiguration research deals with changes in processes [7], statically or dynamically, but neither considers well the long-tailed changes.
There are a huge number of works for coordinating processes. The work in [8] studied various coordination efficiency in different types of collaboration. However, they did not discuss business and emergent situations. Related work has intensively discussed service disruptions due to natural or technical causes [9], and there are many works discussing service and process adaptation under a multitude of technical problems [10]. Important factors and services for enabling resilient business process management have also been analyzed [11]. However, they do not address how existing service development techniques and frameworks would enable us to *quickly implement resilience and elasticity capabilities for deployed services and businesses* to deal with COVID-19 or similar pandemics in which service and business functions are changed due to dynamic policies imposing on workers, goods flow, and customer movements.

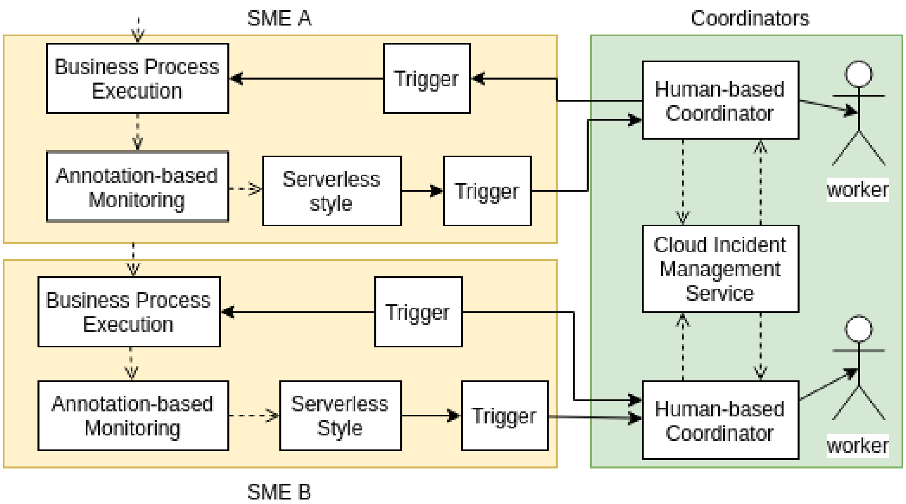

Figure 2: Coordination with human services using incident management services

on-demand as a service, as a collaborative team of a cloud service, a human for collecting data together and another person for changing business processes.

New approach: From the perspective of service information, we have seen additional COVID-19's information about services added into search engines and maps. Quickly, new websites have been deployed and new informal service descriptions are propagated in social media. However, these solutions are without strong technical foundations for service description and integration. We must develop methods to act quickly by annotating information and providing tools that can be used to check service suitability based on pandemic-related contextual information.

From the coordination viewpoint, we see new programming models like serverless [4] facilitating the model coordination-as-a-function with a high degree of the service coordination reactiveness and composition in a rapid development manner. This is especially needed when we combine serverless with the richness of connectors of existing cloud services, including human-based services, via various protocols and interfaces. For example, coordination-as-a-function can be implemented as a serverless function invoking enterprise Web services, collaboration platform as a service (e.g., Microsoft Teams or Slack), or social media (e.g., WeChat) with different programming languages that can be tested and deployed in very short software engineering cycle. Such coordination-as-a-function can be easily deployed into cloud-based serverless platforms with very little effort. They also work well with dynamic triggers based on events from, e.g., Web services and collaboration platforms. From the tooling viewpoint, the low-code approach [15] can enable the provisioning of coordination functions, without/with little coding skills. In terms of dynamic serving, we can implement the coordination model serving using a combination of software and crossover human teams. In pandemic ages, crossover human teams backed by human-based services can play an important role in the coordination model serving.

Towards the implementation:

To address pandemic contextual service information, we should focus on:

- new types of information: new types of service information could characterize pandemic situations and regulations (e.g., social distancing is assured). The contextual model for service information in such situations is location-dependent and business-sector dependent, or even time-variant. In fact during COVID-19, due to specific cultures and resources, we have seen that governance bodies in different places issue so much different policies even for the same safety condition. Not only many micro models must be provided but even with the same context model, instance data/populated data is not the same (e.g., COVID geo-fences). We must incorporate emerging contextual information into service descriptions.

- human-in-the-loop for analytics: as we have observed in pandemic ages, structured and unstructured service information, including service trustworthy information, is disseminated in multiple channels, such as social media, search engine, and traditional Web sites. But, the work of defining context models and populating data might not be automated. In some cases, human-based interpretation is the best way to capture essentials of the situation, e.g., to take the government policy from the right channel and translate the policy into a piece of service information. In terms of service selections, contextual pandemic information, is very much dependent on countries, cities, districts, and even neighborhoods. Therefore, we must leverage human experts, including teams of different types of skills , to assess if new services are compatible. Such a team does not purely evaluate technical constraints but also regulatory compliance. Hence, we need a stronger team formation for pandemic-specific human services as well as support from machine learning for long-tailed services discovery [16] and discovery improvement with social information [17].

To enable fast integration for resilience and elasticity strategies, diverse types of connector platforms must be utilized. In fact, the cloud services provide various software connectors for SMEs. However, connectors specially targeted to human services for SMEs should be added and easily configured, such as similar to ITFFF trigger-action and connectors in Slack. Based on that, serverless and ITFFF programming styles should be explored further to implement quick coordination models. We note that currently, connectors to human services are still primitive, mainly using traditional communication means, like email, SMS, and task assignment, for individuals, whereas connectors for REST-based services and message-oriented, webhook and push-protocol services (like Slack, Wechat) are quite popular. Connectors for invoking high-level human-based services should be explored, such as the use of collectives of software and humans on-demand through low-code trigger-action and configurations. However, collectives are still at an early development stage that requires more research and development effort from practitioners.

Besides, human-based services can be coordination functions during the pandemic, as humans have the best know-how during the pandemic situation. For this, we would not follow "typical programming" but we implement such functions with different tools, e.g., combining message styles and incident management tools. Shown in a conceptual design in Figure 2, within an SME, business processes are augmented with easy-to-use annotations/directives that trigger Service API for elasticity and/or resilience actions (such as a delivery task is not possible or tasks are delayed due to the lack of services). Triggers will invoke human-based coordinators, which either control the business processes or perform other triggers to exchange issues or other requests via messaging systems used in the collaboration, such as Slack, WeChat, or Microsoft Teams. The issues and requests exchanged will trigger human-based coordinators to make a decision on solving elasticity/resilience problems. Messaging systems act as a way to relay issues/requests to deal with elasticity and resilience for human-based coordinators. The coordination work for SMEs can be solved using a virtual team with cloud-based incident services (e.g., PagerDuty [18] or Opsgenie [19]). Collectives of people and software work in a similar manner of incident responses to solve elasticity and resilience for SMEs through on-demand dynamic serving models.

4 Conclusions

Resilience and elasticity strategies for service-based businesses are the key ability to response to the pandemic, such as COVID-19. We must improve solutions for these strategies in tackling the disruption of services due to long-tailed business changes in SMEs. Our observations emphasize the critical points of coordination and service information in assuring service continuity through the implementation of resilience and elasticity. For solving issues of business disruption, we recommend focusing on service compatibility, coordination programming, and coordination serving techniques that could utilize serverless, low-code, human-in-the-loop, and pandemic-contextual information. A longer version of our work summarized in this paper is available at `https://bit.ly/3zlorNk`.

Bio

Hong-Linh Truong is an associate professor at Aalto University, Finland. Contact him at linh.truong@aalto.fi.
Liang Zhang is a professor at Fudan University, China. Contact him at lzhang@fudan.edu.cn

References

[1] T. Weil and S. Murugesan, "IT risk and resilience - cybersecurity response to COVID-19," *IT Prof.*, vol. 22, no. 3, pp. 4–10, 2020.

[2] Budd, J., Miller, B.S., Manning, E.M. et al, "Digital technologies in the public-health response to covid-19," *Nature Medicine*, vol. 26, no. 8, pp. 1183–1192, Aug 2020.

[3] T. Weil, B. Unhelkar, J. Callahan, J. W. Rupe, and K. Sherringham, "It pro special issue on communications recovery and resilienceâ€"editor's column," *IT Professional*, vol. 22, no. 06, pp. 24–25, 2020.

[4] J. Schleier-Smith, V. Sreekanti, A. Khandelwal, J. Carreira, N. J. Yadwadkar, R. A. Popa, J. E. Gonzalez, I. Stoica, and D. A. Patterson, "What serverless computing is and should become: The next phase of cloud computing," *Commun. ACM*, vol. 64, no. 5, p. 76–84, Apr. 2021.

[5] IFTTT: Every thing works better together. Last access: April 8, 2020. [Online]. Available: https://ifttt.com/

[6] W. Kongdenfha, H. R. Motahari-Nezhad, B. Benatallah, F. Casati, and R. Saint-Paul, "Mismatch patterns and adaptation aspects: A foundation for rapid development of web service adapters," *IEEE Trans. Serv. Comput.*, vol. 2, no. 2, p. 94–107, Apr. 2009.

[7] W. Song and H. Jacobsen, "Static and dynamic process change," *IEEE Transactions on Services Computing*, vol. 11, no. 1, pp. 215–231, 2018.

[8] D. M. Romero, D. Huttenlocher, and J. M. Kleinberg, "Coordination and efficiency in decentralized collaboration," *CoRR*, vol. abs/1503.07431, 2015.

[9] C. Wankmüller and G. Reiner, "Coordination, cooperation and collaboration in relief supply chain management," *Journal of Business Economics*, vol. 90, no. 2, pp. 239–276, 2020.

[10] D. R. Mathews and J. Lakshmi, "Service resilience framework for enhanced end-to-end service quality," in *Proceedings of the 18th Workshop on Adaptive and Reflexive Middleware.* Association for Computing Machinery, 2019, p. 7–12.

[11] P. Antunes and H. Mourão, "Resilient business process management: Framework and services," *Expert Systems with Applications*, vol. 38, no. 2, pp. 1241 – 1254, 2011.

[12] S. Ma, Y. Chen, Y. Syu, H. Lin, and Y. Fan-Jiang, "Test-oriented restful service discovery with semantic interface compatibility," *IEEE Transactions on Services Computing*, pp. 1–1, 2018.

[13] T. Yu, Y. Zhang, and K.-J. Lin, "Efficient algorithms for web services selection with end-to-end qos constraints," *ACM Trans. Web*, vol. 1, no. 1, p. 6–es, May 2007.

[14] Zapier. Last access: Feb 15, 2021. [Online]. Available: https://zapier.com

[15] M. Woo, "The rise of no/low code software development—no experience needed?" *Engineering*, vol. 6, no. 9, pp. 960–961, 2020.

[16] B. Bai, Y. Fan, W. Tan, and J. Zhang, "Dltsr: A deep learning framework for recommendations of long-tail web services," *IEEE Transactions on Services Computing*, vol. 13, no. 1, pp. 73–85, 2020.

[17] T. Liang, L. Chen, J. Wu, G. Xu, and Z. Wu, "Sms: A framework for service discovery by incorporating social media information," *IEEE Transactions on Services Computing*, vol. 12, no. 3, pp. 384–397, 2019.

[18] PagerDuty. Last access: Feb 15, 2021. [Online]. Available: https://www.pagerduty.com/

[19] OpsGenie. Last access: Feb 15, 2021. [Online]. Available: https://www.atlassian.com/software/opsgenie