TEAM TOPOLOGIES

ORGANIZING BUSINESS AND TECHNOLOGY TEAMS FOR FAST FLOW

Foreword by RUTH MALAN

MATTHEW SKELTON *and* MANUEL PAIS

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Team Topologies

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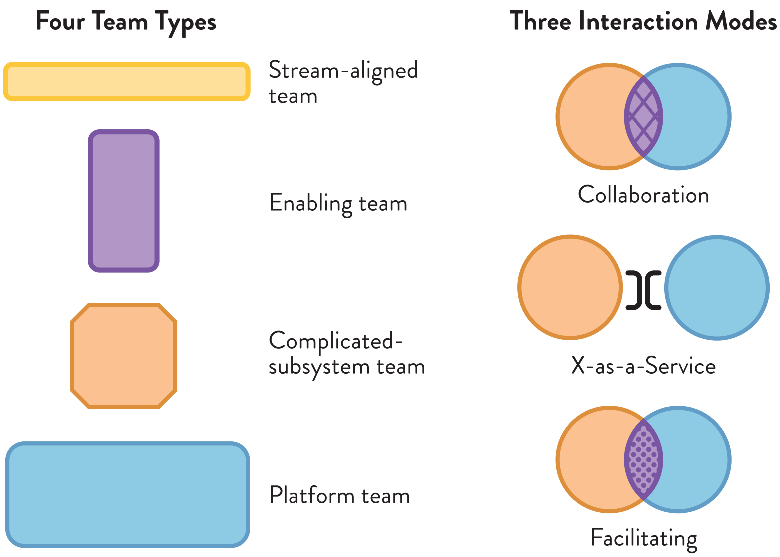

Figure 0.1: The Four Team Types and Three Interaction Modes

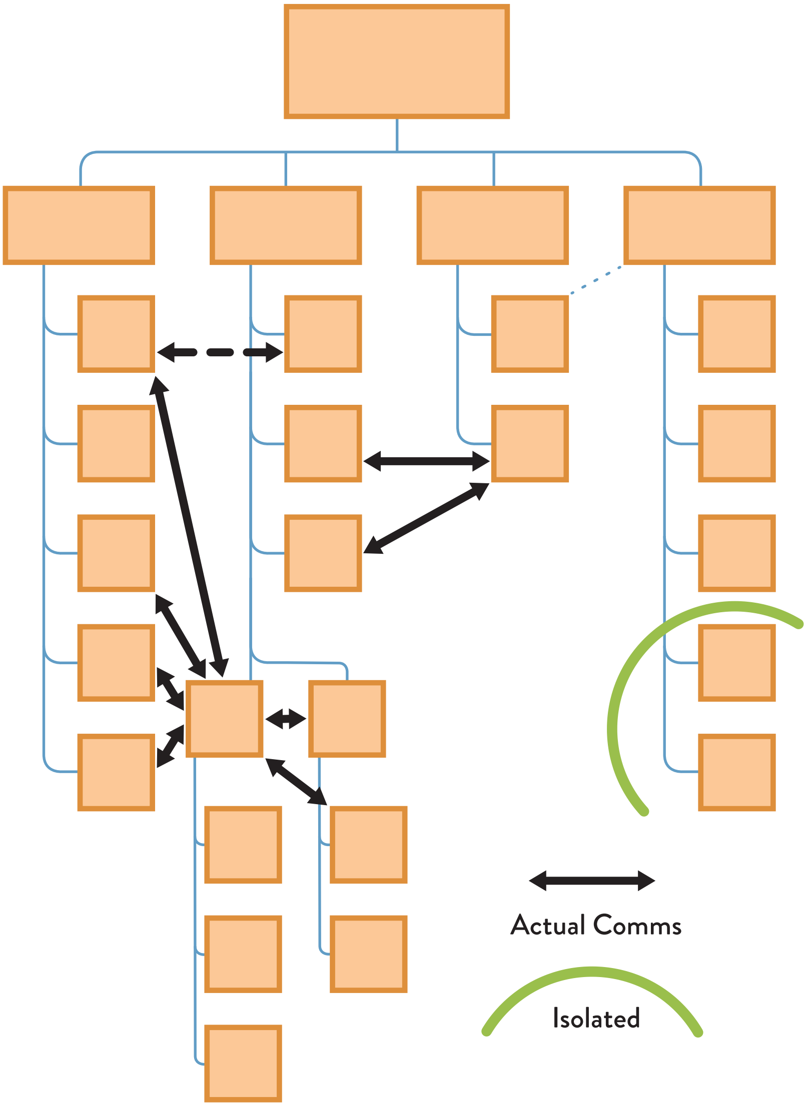

Figure 1.1: Org Chart with Actual Lines of Communication
In practice, people communicate laterally or "horizontally" with people from other reporting lines in order to get work done. This creativity and problem solving needs to be nurtured for the benefit of the organization, not restricted to optimize for top-down/bottom-up communication and reporting.

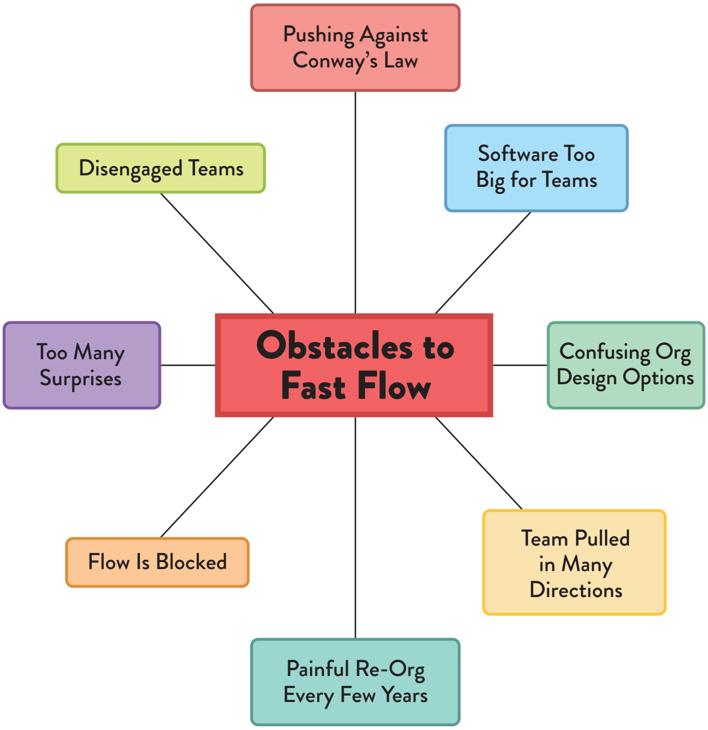

Figure 1.2: Obstacles to Fast Flow

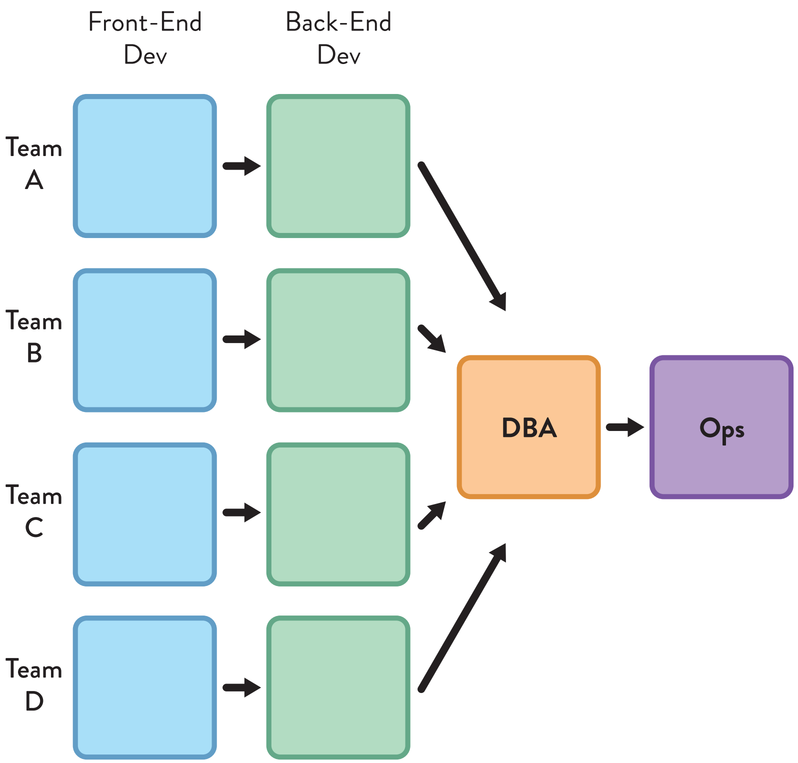

Figure 2.1: Four Teams Working on a Software System
Four separate teams consisting of front-end and back-end developers work on a software system. Front-end devs communicate only with back-end devs, who communicate with a single DBA for the database changes.

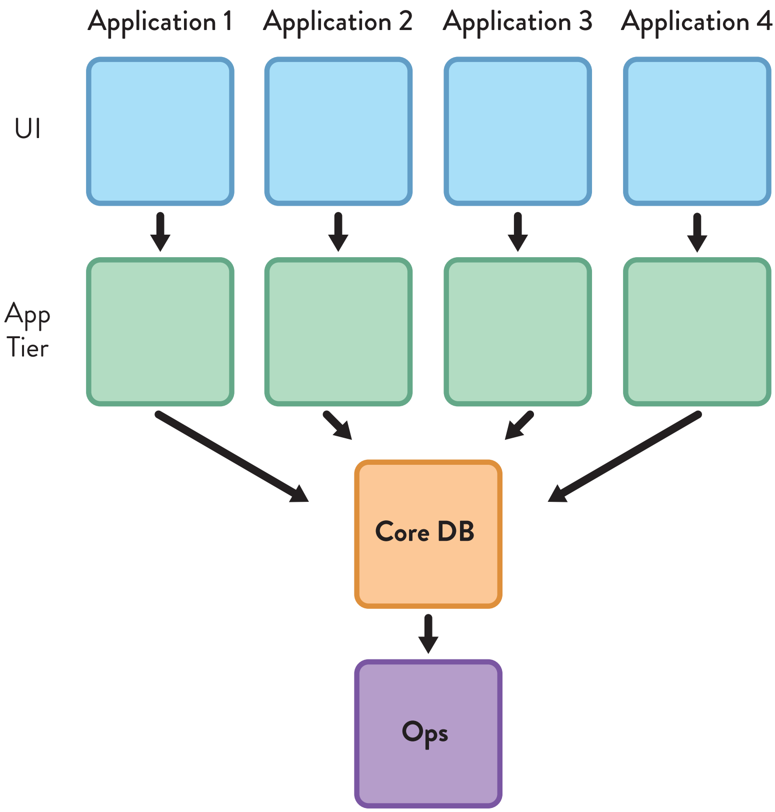

Figure 2.2: Software Architecture from Four-Team Organization
Four separate applications, each with a separate user interface (UI) and a back-end application tier that communicate with a single shared database. This reflects and matches the team communication architecture from Figure 2.1; the diagram has simply been rotated ninety degrees.

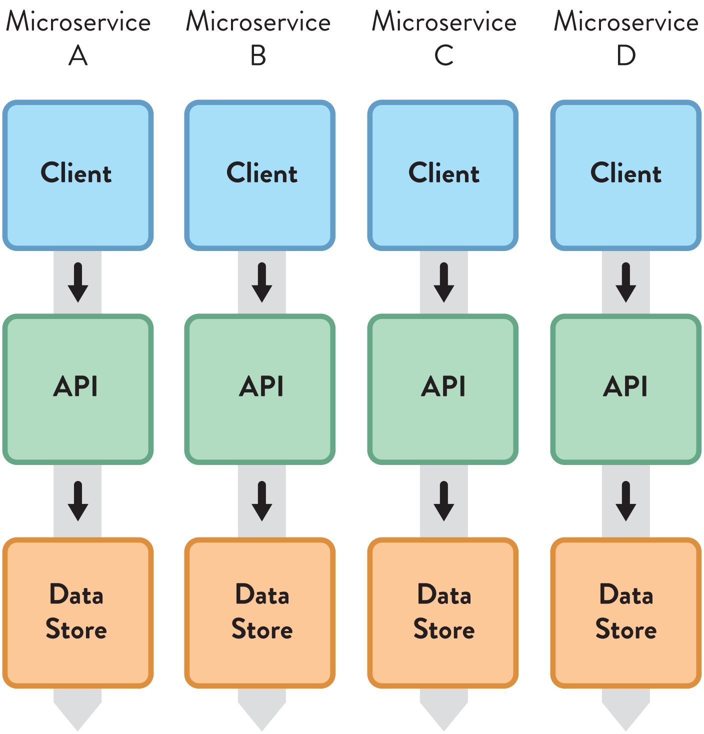

Figure 2.3: Microservices Architecture with Independent Services and Data Stores
A microservices-based architecture with four separate services, each with its own data store, API layer, and front-end client.

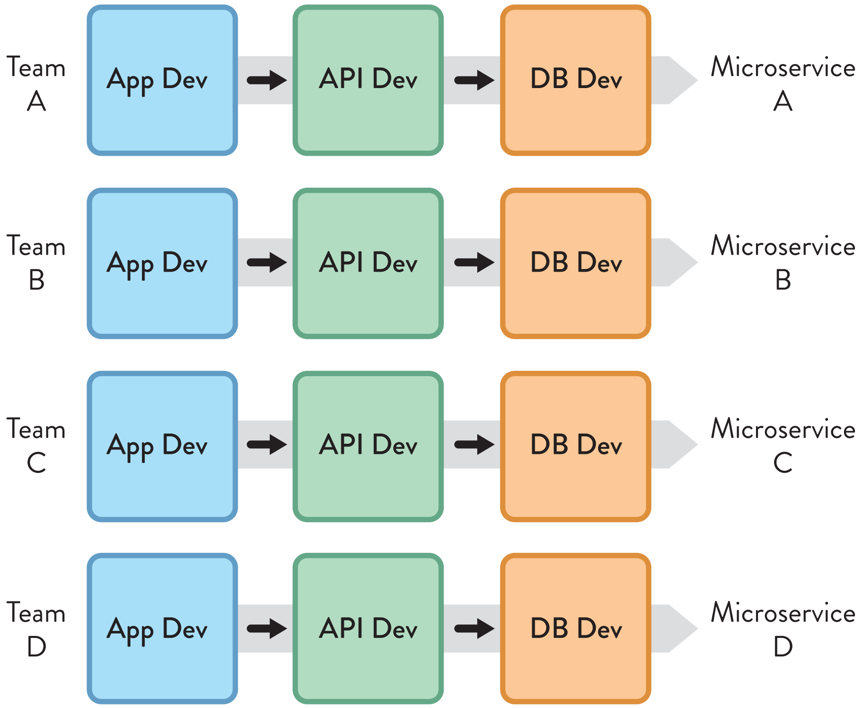

Figure 2.4: Team Design for Microservices Architecture with Independent Services and Data Stores

An organization design that anticipates the homomorphic force behind Conway's law to help produce a software architecture with four independent microservices. (Again, this is basically the diagram in Figure 2.3 rotated ninety degrees.)

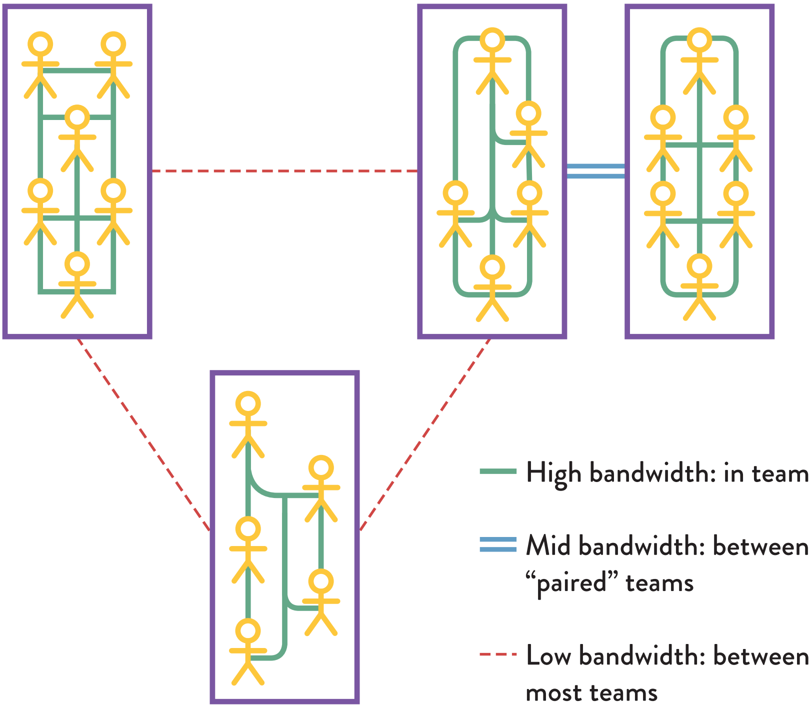

Figure 2.5: Inter-Team Communication
Communication within teams is high bandwidth. Communication between two "paired" teams can be mid bandwidth. Communication between most teams should be low bandwidth.

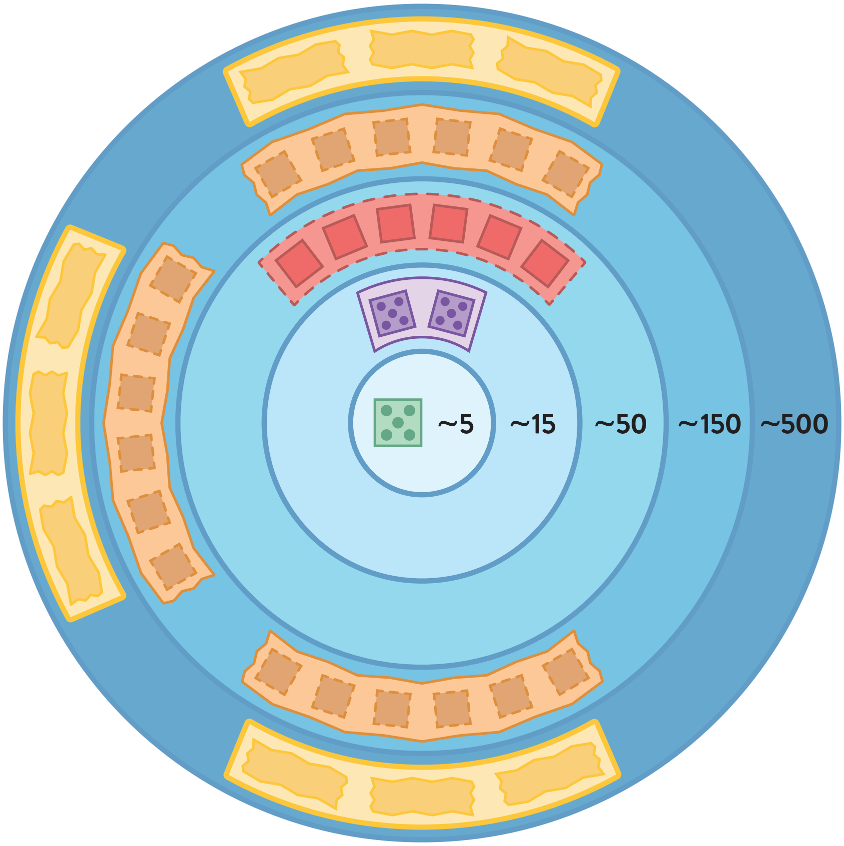

Figure 3.1: Scaling Teams Using Dunbar's Number
Organizational groupings should follow Dunbar's number, beginning with around five people (or eight for software teams), then increasing to around fifteen people, then fifty, then 150, then 500, and so on.

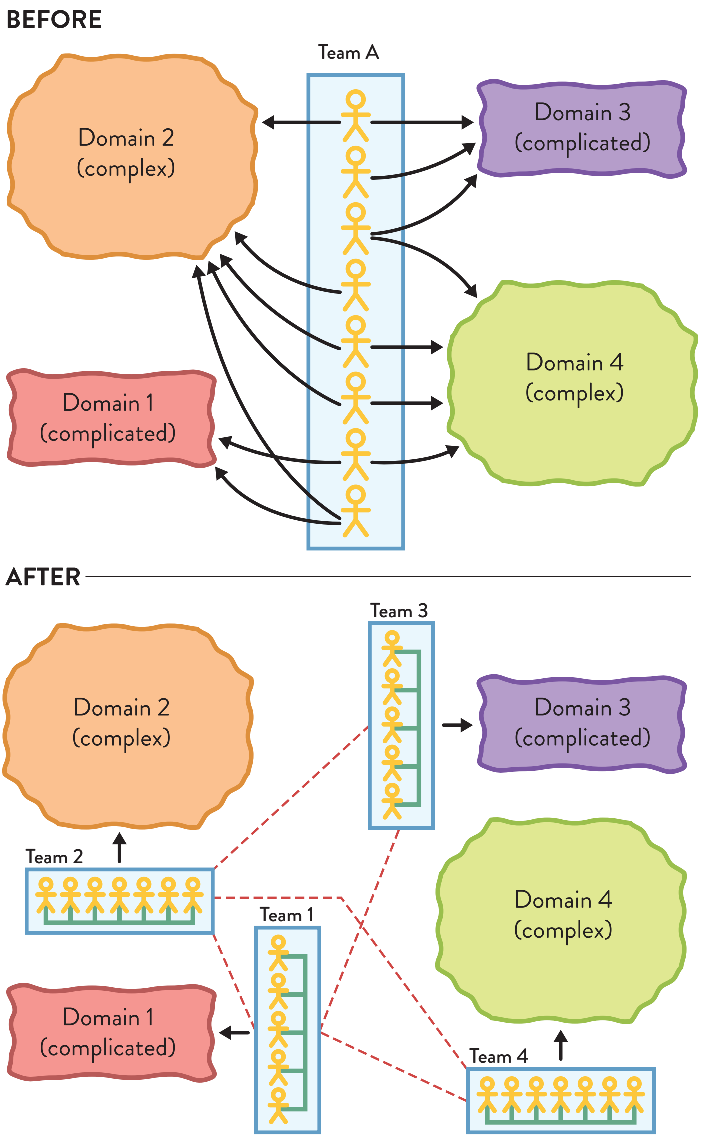

Figure 3.2: No More than One Complicated or Complex Domain per Team
Before: a larger team is spread thin across four domains (two complicated and two complex) and struggles to perform well. Intra-team morale is negatively affected, with frequent context switches and individual disengagement. After: with multiple smaller teams each focusing on a single domain, motivation rises and the team delivers faster and more predictably. Low bandwidth inter-team collaboration allows solving occasional issues affecting two or more domains.

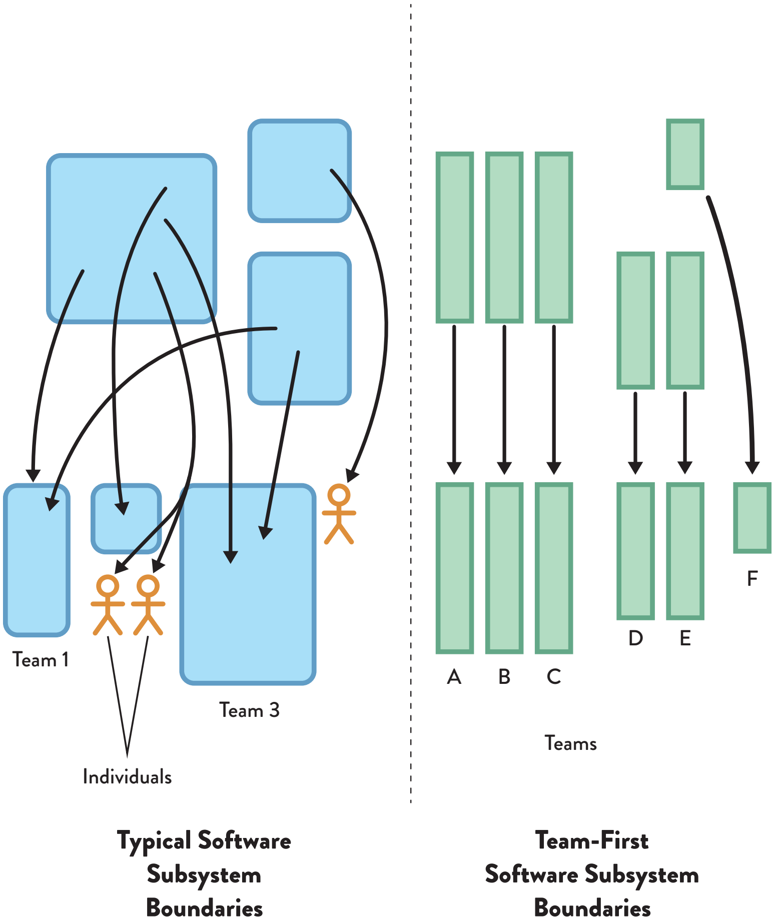

Figure 3.3: Typical vs. Team-First Software Subsystem Boundaries

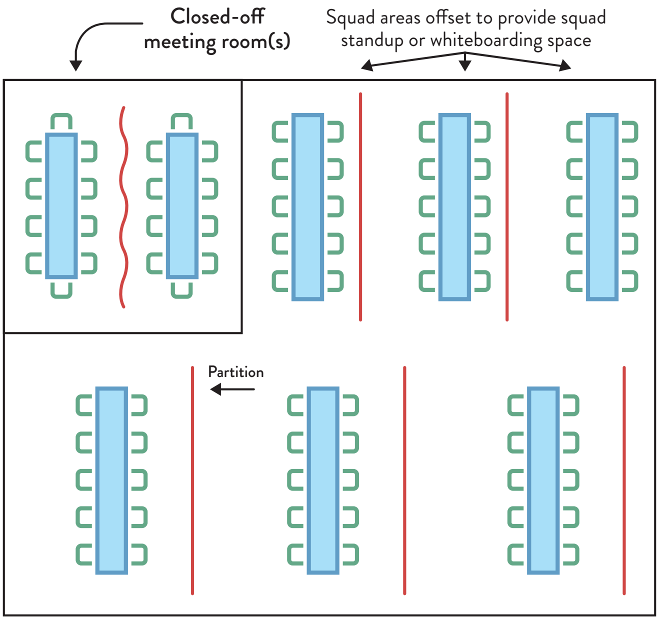

Figure 3.4: Office Layout at CDL

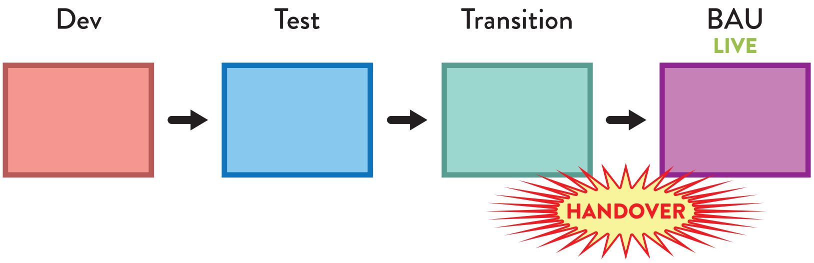

Figure 4.1: Organization not Optimized for Flow of Change
Traditional flow of change in an organization not optimized for flow, with a series of groups owning different activities and handing over the work to the next team. No information flows back from the live systems into teams building the software.

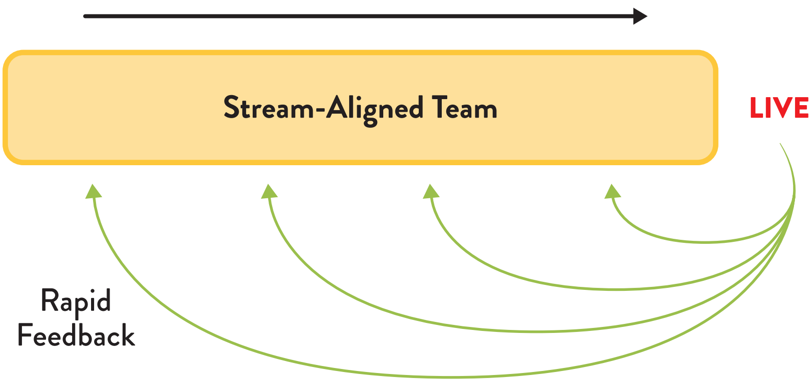

Figure 4.2: Organization Optimized for Flow of Change
Organizations set up for fast flow avoid hand-offs by keeping work within the stream-aligned team, and they ensure that the rich set of operational information flows back into the team.

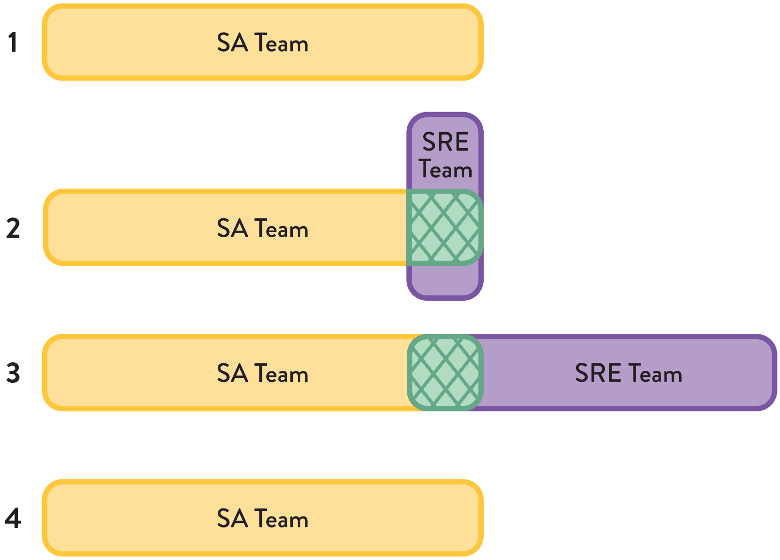

Figure 4.3: Relationship between SRE Team and Application Team

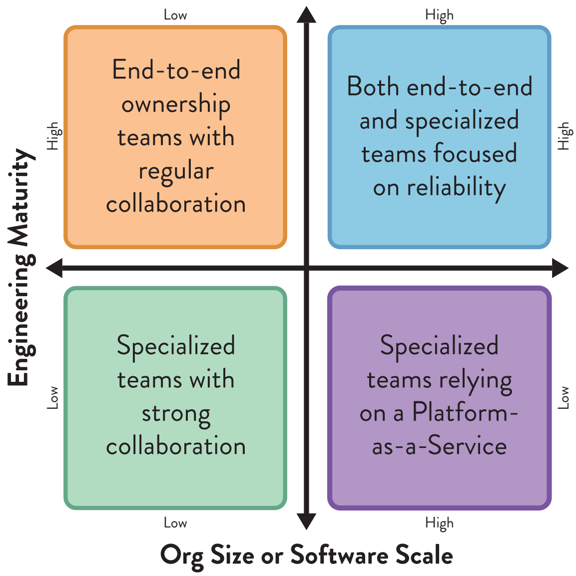

Figure 4.4: Influence of Size and Engineering Maturity on Choice of Topologies
Organization size (or software scale) and engineering discipline influence the effectiveness of team interaction patterns.

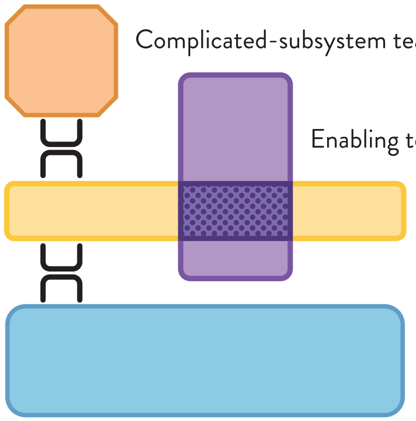

Figure 5.1: The Four Fundamental Team Topologies

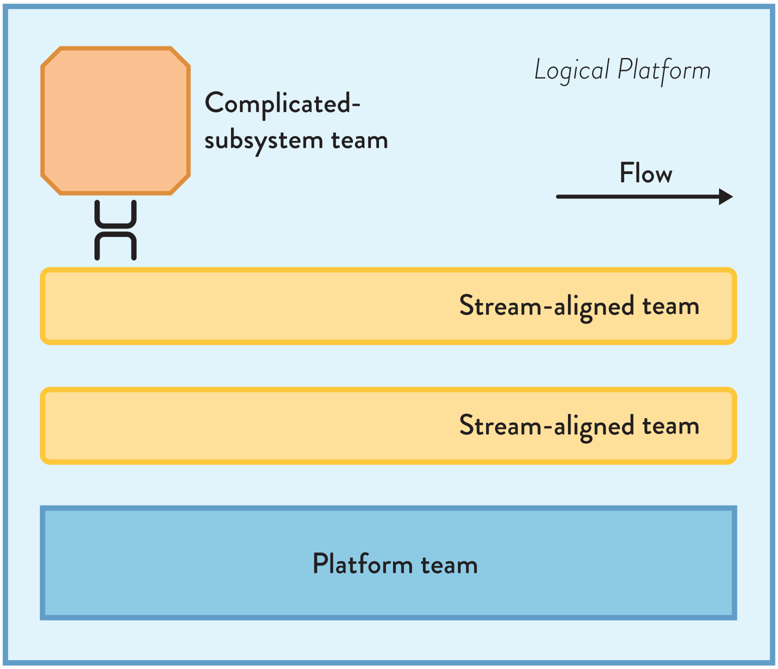

Figure 5.2: Platform Composed of Several Fundamental Team Topologies
In a large organization, the platform is composed of several other fundamental team topologies: stream-aligned Dev teams, complicated-subsystem teams, and a lower-level platform.

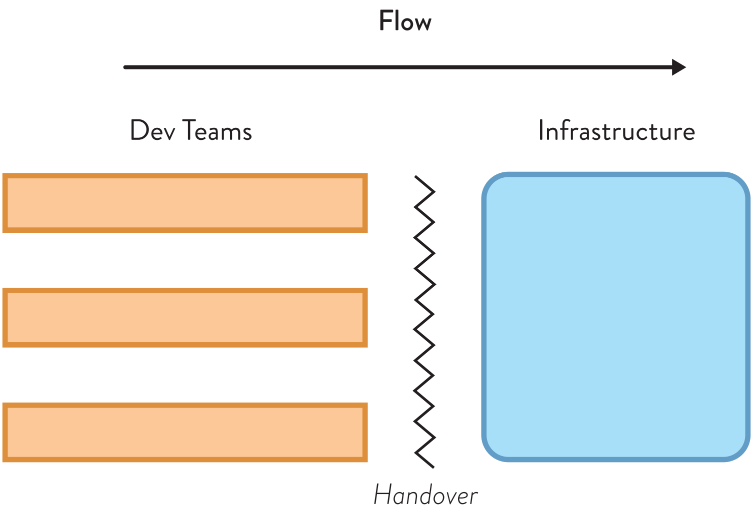

Figure 5.3: Traditional Infrastructure Team Organization
Many traditional infrastructure teams (on the right) blocked flow by being responsible for all changes to production infrastructure, including application changes, frequently gated by ITIL change processes. Work from Dev teams (on the left) was handed over to infrastructure or Ops teams for deployment, preventing flow.

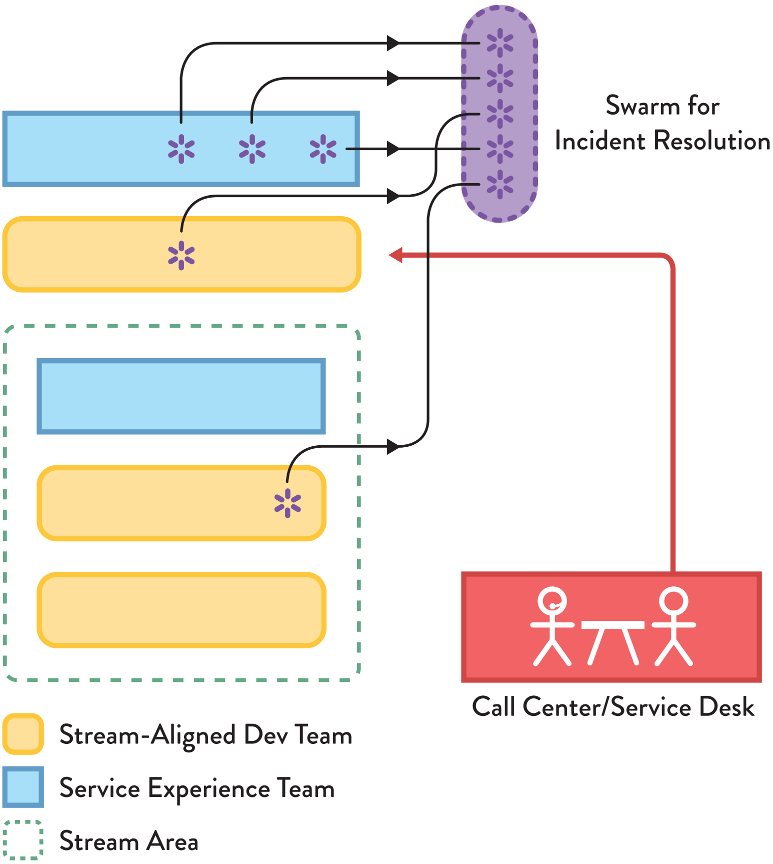

Figure 5.4: Support Teams Aligned to Stream of Change
The new model for support teams: aligned to the flow of change, usually paired with one or more stream-aligned Dev teams. Incidents are handled with dynamic "swarming."

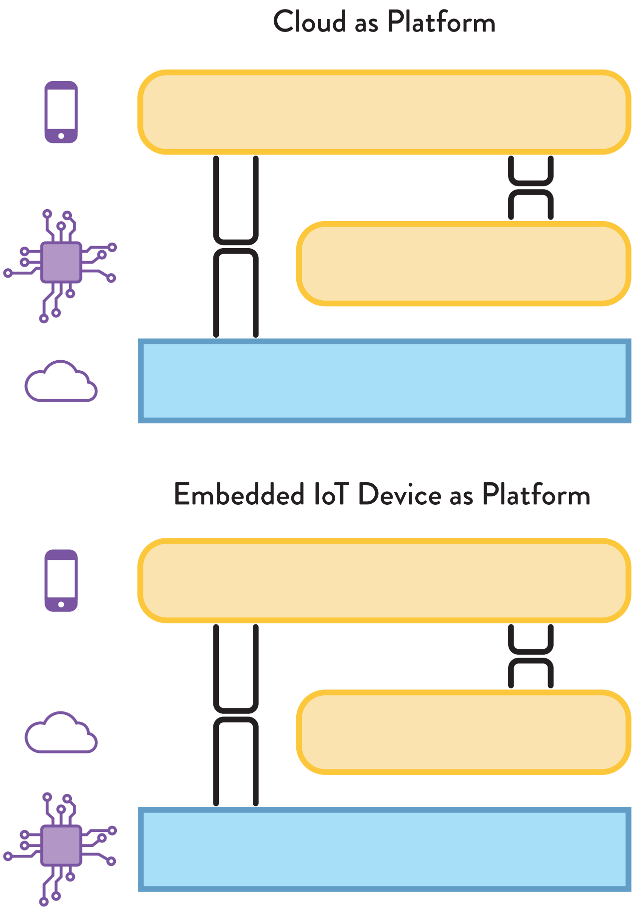

Figure 6.1: Mobile, Cloud, and IoT Technology Fracture Plane Scenario
With three very disparate technologies (mobile, cloud, and IoT), an organization must decide on an approach to fracture planes that makes sense based on the cognitive load and the change cadence in each area.

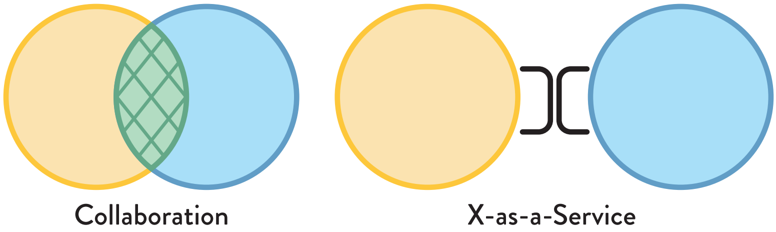

Figure 7.1: Collaboration vs. X-as-a-Service
Collaboration means explicitly working together on defined areas. X-as-a-Service means one team consumes something "as a service" from another team.

Figure 7.2: The Three Team Interaction Modes
Collaboration mode is shown with diagonal cross-hatching, X-as-a-Service mode is shown with brackets, and facilitating is shown with dots.

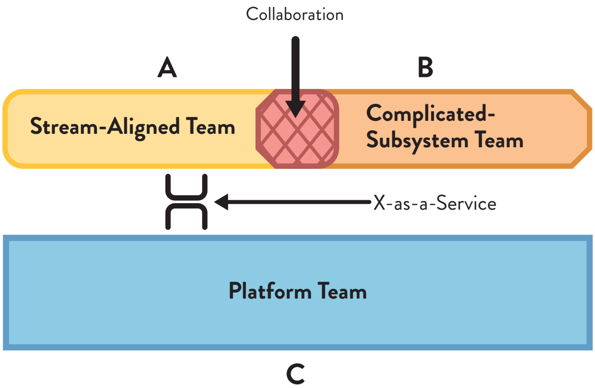

Figure 7.3: Team Interaction Modes Scenario
Stream-aligned Team A collaborates with complicated-subsystem Team B (shown with cross-hatching) while also consuming the platform provided by Team C, using the X-as-a-Service mode (shown with brackets).

Table 7.1: Advantages and Disadvantages of Collaboration Mode

Advantages	Disadvantages
• Rapid innovation and discovery • Fewer hand-offs	• Wide, shared responsibility for each team • More detail/context needed between teams, leading to higher cognitive load • Possible reduced output during collaboration compared to before
Constraint: A team should use collaboration mode with, at most, one other team at a time. A team should not use collaboration with more than one team at the same time.	
Typical Uses: Stream-aligned teams working with complicated-subsystem teams; stream-aligned teams working with platform teams; complicated-subsystem teams working with platform teams	

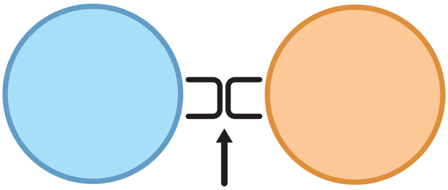

Figure 7.4: X-as-a-Service Team Interaction Mode
In this case, the team on the right is providing something "as a service" to the team on the left (perhaps an API, some developer tooling, or even an entire platform).

Table 7.2: Advantages and Disadvantages of X-as-a-Service Mode

Advantages	Disadvantages
• Clarity of ownership with clear responsibility boundaries • Reduced detail/context needed between teams, so cognitive load is limited	• Slower innovation of the boundary or API • Danger of reduced flow if the boundary or API is not effective
Constraint: A team should expect to use the X-as-a-Service interaction with many other teams simultaneously, whether consuming or providing a service.	
Typical Uses: Stream-aligned teams and complicated-subsystem teams consuming Platform-as-a-Service from a platform team; stream-aligned teams and complicated-subsystem teams consuming a component or library as a service from a complicated-subsystem team.	

Table 7.3: Advantages and Disadvantages of Facilitation Mode

Advantages	Disadvantages
• Unblocking of stream-aligned teams to increase flow • Detection of gaps and misaligned capabilities or features in components and platforms	• Requires experienced staff to not work on "building" or "running" things • The interaction may be unfamiliar or strange to one or both teams involved in facilitation
Constraint: A team should expect to use the facilitating interaction mode with a small number of other teams simultaneously, whether consuming or providing the facilitation.	
Typical Uses: An enabling team helping a stream-aligned, complicated-subsystem, or platform team; or a stream-aligned, complicated-subsystem, or platform team helping a stream-aligned team.	

Table 7.4: Team interaction modes of the fundamental team topologies

	Collaboration	X-as-a-Service	Facilitating
Stream-aligned	Typical	Typical	Occasional
Enabling	Occasional		Typical
Complicated-subsystem	Occasional	Typical	
Platform	Occasional	Typical	

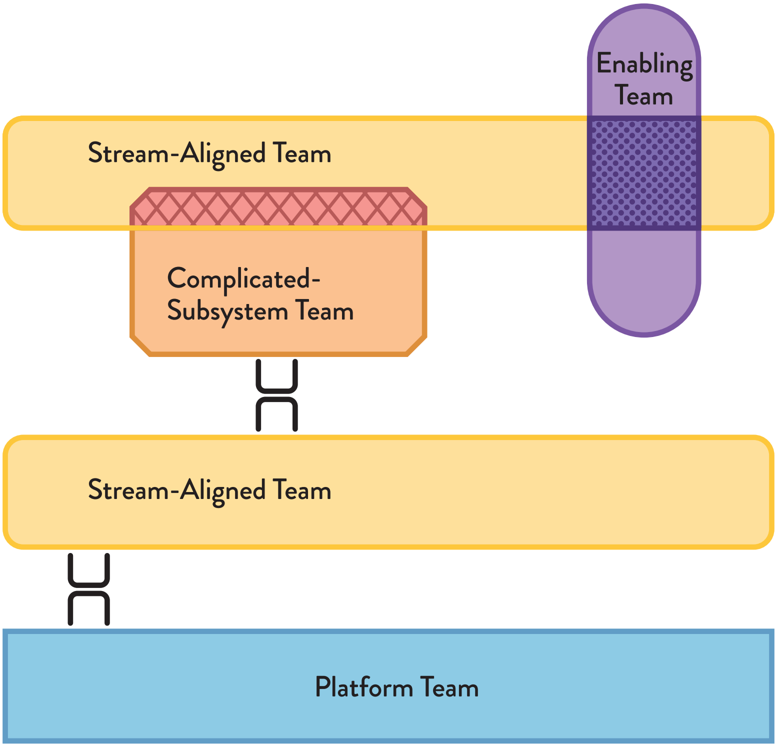

Figure 7.5: Primary Interaction Modes for the Four Fundamental Team Topologies
Stream-aligned teams use X-as-a-Service or collaboration; enabling teams use facilitation; complicated-subsystem teams use X-as-a-Service; platform teams use X-as-a-Service for teams that consume the platform.

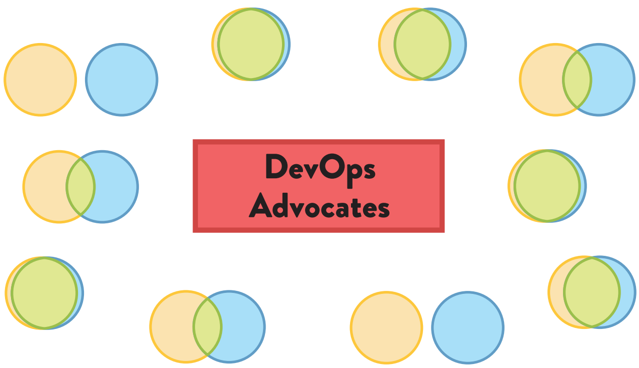

Figure 7.6: Team Interaction Modes at IBM around 2014
Team interaction modes at IBM around 2014, with a team of "DevOps advocates" coordinating and facilitating learning and team changes.

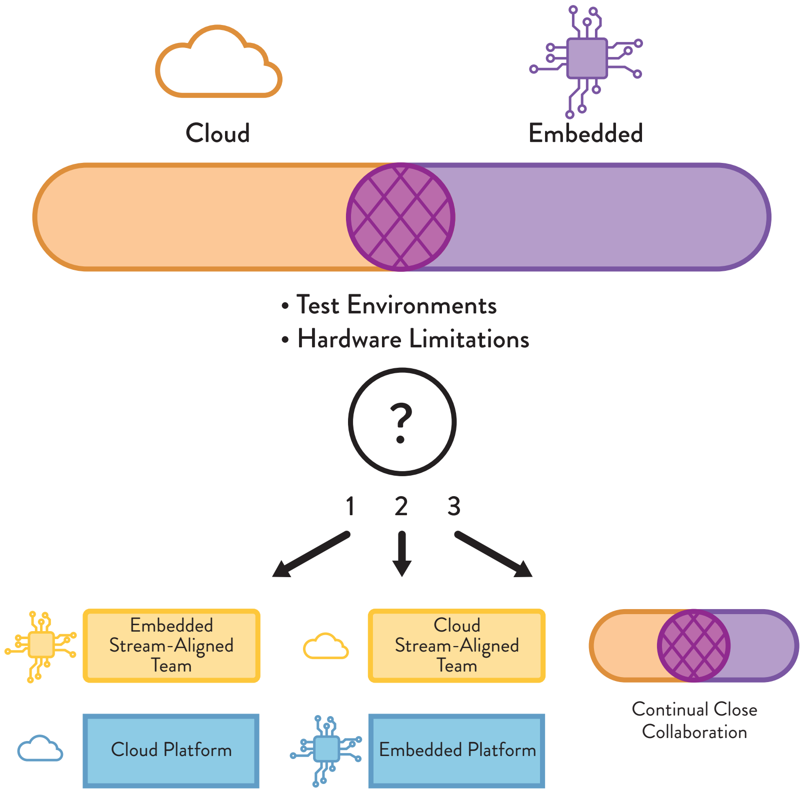

Figure 8.1: Collaboration between Cloud and Embedded Teams
Two teams ("cloud" and "embedded") collaborate to share practices and increase awareness. The results will include heightened awareness of the options for future team interactions: (1) treat the cloud software as a platform for the embedded team to use, (2) treat the embedded devices as a platform for the cloud team to use, or (3) continue with close collaboration.

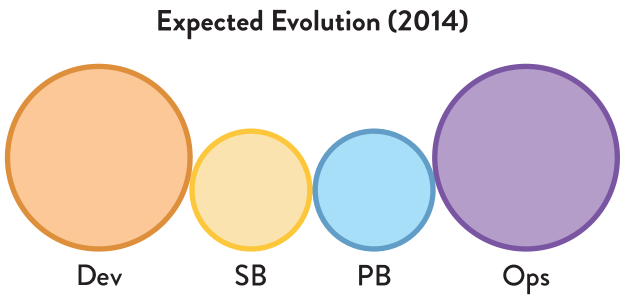

Figure 8.2: System-Build and Platform-Build Team at TransUnion
A team from Dev (SB) and a team from Ops (PB) exploring close interactions.

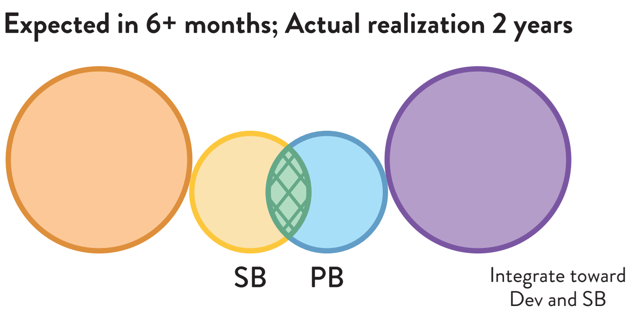

Figure 8.3: System-Build and Platform-Build Team Collaboration at TransUnion
The two teams, SB and PB, collaborating closely.

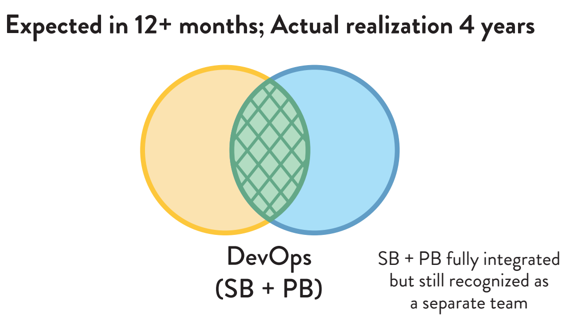

Figure 8.4: System-Build and Platform-Build Teams Merged at TransUnion
The SB and PB teams merged, helping to bring Dev and Ops together.

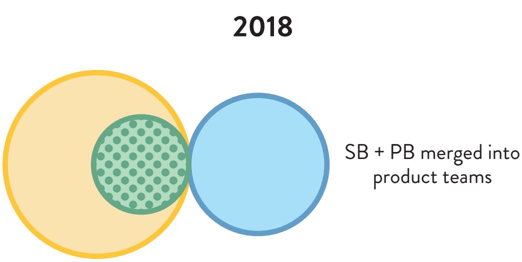

Figure 8.5: System-Build and Platform-Build Teams Merged Back into Dev and Ops at TransUnion

The SB and PB teams merged back into Dev and Ops, providing Platform-as-a-Service.

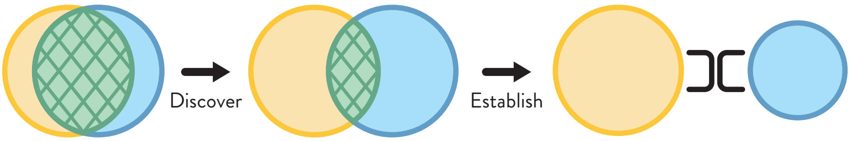

Figure 8.6: Evolution of Team Topologies
The evolution of Team Topologies from close collaboration to limited collaboration (discovery) through to X-as-a-Service for established, predictable delivery.

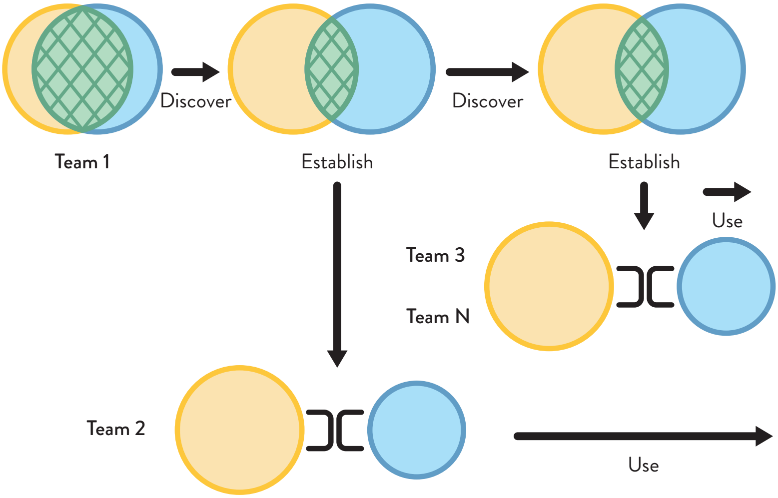

Figure 8.7: Evolution of Team Topologies in an Enterprise
Team 1 continues to collaborate with a platform team, discovering new patterns and ways of using new technologies. This discovery activity eventually enables Team 2 to adopt an X-as-a-Service relationship with the platform team. Later, Teams 3 and beyond adopt a later version of the platform, using it as a service without having to collaborate closely with the platform team.

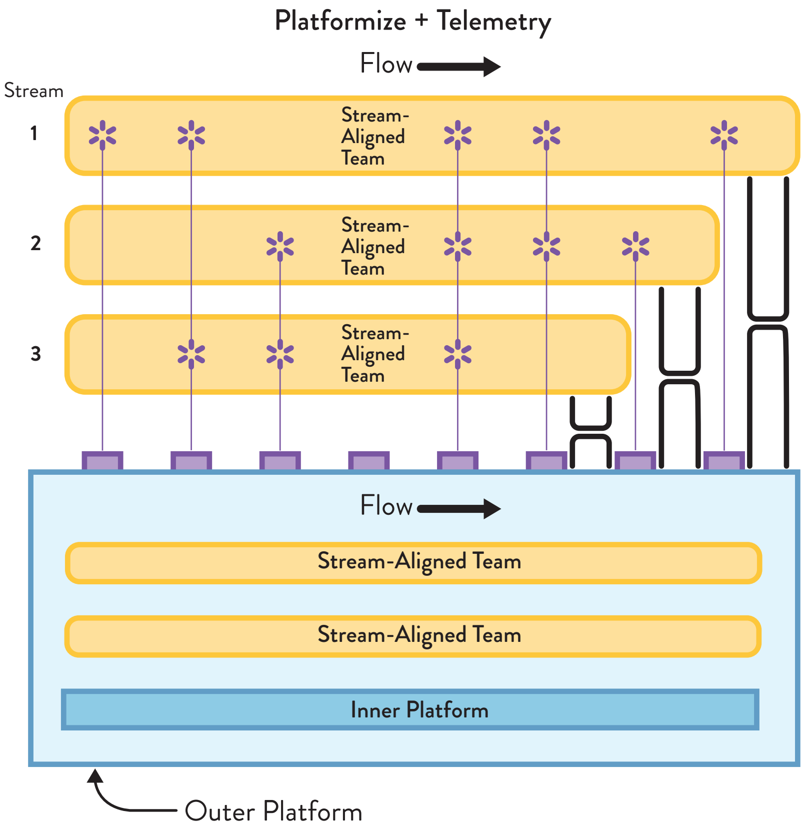

Figure 8.8: Example of a "Platform Wrapper"

Increase flow predictability in higher-level business services (streams) through the use of a "platform wrapper" to "platformize" the lower-level services and APIs, allowing the streams to treat all their dependencies as a single platform with a holistic roadmap and consistent DevEx. The streams also have rich telemetry to track flow and resource usage of the platform.

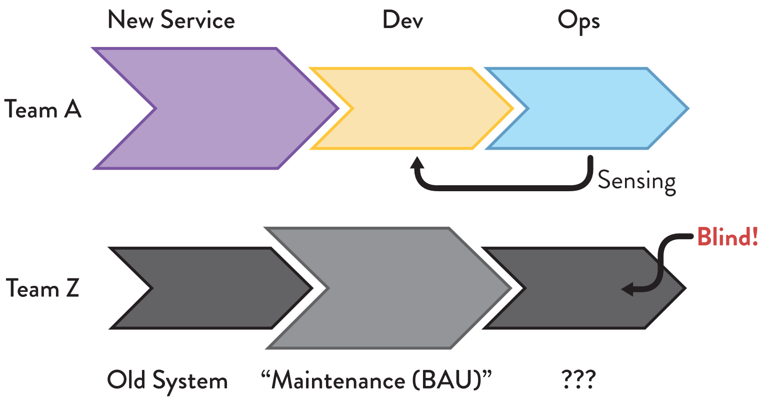

Figure 8.9: New-Service and "Business as Usual" (BAU) Teams
Having separate teams for "new stuff" and BAU tends to prevent learning, improvements and ability to self-steer. It is a non-cybernetic approach.

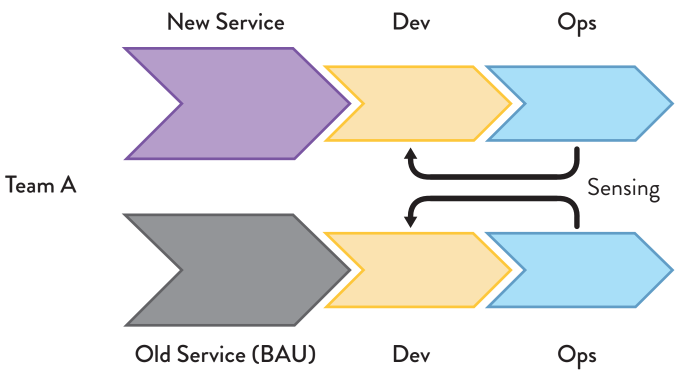

Figure 8.10: Side-by-Side New Service and BAU Teams
A cybernetic approach to maintaining older systems has a single stream-aligned team (or pair of teams) developing and running the new service *and* the older systems, enabling the team to retro-fit newer telemetry to the older system and increase the fidelity of the sensing from both systems.

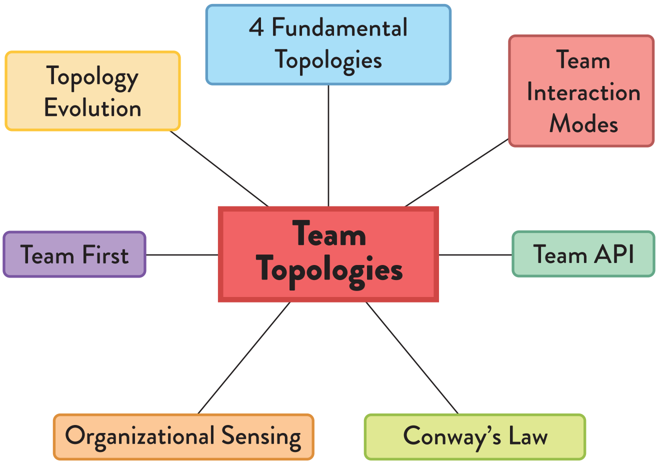

Figure 9.1: Core Ideas of Team Topologies

GLOSSARY

API (application programming interface): a description and specification for how to interact programmatically with software.

application monolith: a single, large application with many dependencies and responsibilities that possibly exposes many services and/or different user journeys.

bounded context: a unit for partitioning a larger domain (or system) model into smaller parts, each of which represents an internally consistent business domain area.

Brooks's law: law coined by Fred Brooks which states that adding new people to a team doesn't immediately increase the capacity of a team.

cognitive load: the amount of working memory being used.

collaboration mode: team(s) working closely together with another team.

complicated-subsystem team: responsible for building and maintaining a part of the system that depends heavily on specialist knowledge.

Conway's law: law coined by Mel Conway that states that system design will copy the communication structures of the organization which designs it.

domain complexity: how complex the problem is that is being solved via software.

Dunbar's number: coined by anthropologist Robin Dunbar, which states that fifteen is the limit of people one person can trust; of those, only around five can be known and trusted closely.

enabling team: team(s) composed of specialists in a given technical (or product) domain; they help bridge the capability gap.

extraneous cognitive load: relates to the environment in which the task is being done (e.g., "How do I deploy this component, again?" "How do I configure this service?").

facilitating mode: team(s) helping (or being helped by) another team to clear impediments.

flow of change: a stream of related updates or alterations to a software service or system, usually aligned to user goals or other core focus of the business.

fracture plane: a natural “seam” in the software system that allows it to be easily split into two or more parts.

germane cognitive load: relates to aspects of the task that need special attention for learning or high performance (e.g., “How should this service interact with the ABC service?”).

intrinsic cognitive load: relates to aspects of the task fundamental to the problem space (e.g., “What is the structure of a Java class?” “How do I create a new method?”).

joined-at-the-database monolith: composed of several applications or services all coupled to the same database schema, making them difficult to change, test, and deploy separately.

monolithic build: uses one gigantic continuous integration (CI) build to get a new version of a component.

monolithic model: software that attempts to force a single domain language and representation (format) across many different contexts.

monolithic release: a set of smaller components bundled together into a “release.”

monolithic thinking: “one-size-fits-all” thinking for teams that leads to unnecessary restrictions on technology and implementation approaches between teams.

monolithic workplace: a single office layout pattern for all teams and individuals in the same geographic location.

organizational sensing: teams and their internal and external communication are the “senses” of the organization (sight, sound, touch, smell, taste).

platform team: enables stream-aligned teams to deliver work with substantial autonomy.

reverse Conway maneuver: organizations should evolve their team and organizational structure to achieve the desired architecture.

stream-aligned team: a team aligned to a single, valuable stream of work.

team API: an API surrounding each team.

Team Topologies: model for organizational design that provides a key technology-agnostic mechanism for modern software-intensive enterprises to sense when a change in strategy is required (either from a business or technology point of view).

thinnest viable platform: a careful balance between keeping the platform small and ensuring that the platform is helping to accelerate and simplify software delivery for teams building on the platform.

X-as-a-Service mode: consuming or providing something with minimal collaboration.

RECOMMENDED READING

Key Management Concepts and Practices for Reliable, Fast Flow

- *Accelerate: The Science of Lean Software and DevOps: Building and Scaling High Performing Technology Organizations* by Nicole Forsgren, PhD, Jez Humble, and Gene Kim (Portland, Oregon: IT Revolution, 2018).
- *Designing Delivery: Rethinking IT in the Digital Service Economy* by Jeff Sussna (Beijing: O'Reilly Media, 2015).
- *Fearless Change: Patterns for Introducing New Ideas* by Mary Lynn Manns and Linda Rising (Boston: Addison Wesley, 2004).

Key Practices and Approaches for Organizations, Software, and Systems

- *Team Genius: The New Science of High-Performing Organizations* by Rich Karlgaard and Michael S. Malone (New York, NY: HarperBusiness, 2015).
- *Agile Development in the Large: Diving into the Deep* by Jutta Eckstein (New York: Dorset House Publishing Co Inc.,US, 2004).
- *Domain-Driven Design: Tackling Complexity in the Heart of Software* by Eric Evans (Boston: Addison-Wesley, 2003).
- *Thinking in Promises* by Mark Burgess (Sebastopol, California: O'Reilly Media, 2015).

Key Engineering Practices that Enable Fast Flow

- *Continuous Delivery: Reliable Software Releases through Build, Test, and Deployment Automation* by Jez Humble and David Farley (Upper Saddle River, NJ: Addison Wesley, 2010).

- *Release It! Design and Deploy Production-Ready Software* by Michael T. Nygard (Raleigh, North Carolina: O'Reilly, 2018).
- *Team Guide to Software Operability*, Team Guide Series 1, by Matthew Skelton and Rob Thatcher (Leeds, UK: Conflux Books, 2016).
- *Team Guide to Software Testability*, Team Guide Series 3, by Ash Winter and Rob Meaney (Leeds, UK: Conflux Books, 2018).
- *Team Guide to Software Releasability*, Team Guide Series 4, by Manuel Pais and Chris O'Dell (Leeds, UK: Conflux Books, 2018).

REFERENCES

Ackoff, Russell L. *Re-Creating the Corporation: A Design of Organizations for the 21st Century*. Oxford: Oxford University Press, 1999.

Ackoff, Russell L., Herbert J. Addison, and Sally Bibb. *Management F-Laws: How Organizations Really Work*. United Kindgom, Triarchy Press, 2007.

Adams, Paul. "Scaling Product Teams: How to Build and Structure for Hypergrowth." *Inside Intercom* (blog). January 28, 2015. https://www.intercom.com/blog/how-we-build-software/.

Adkins, Lyssa. *Coaching Agile Teams: A Companion for ScrumMasters, Agile Coaches, and Project Managers in Transition*. Upper Saddle River, NJ: Addison-Wesley Professional, 2010.

Allen, Thomas J. *Managing the Flow of Technology*. Cambridge, MA: MIT Press, 1984.

Allspaw, John. "Blameless PostMortems and a Just Culture." *Code as Craft* (blog), May 22, 2012. https://codeascraft.com/2012/05/22/blameless-postmortems/.

Almeida, Thiago. "DevOps Lessons Learned at Microsoft Engineering." *InfoQ*, May 22, 2016. https://www.infoq.com/articles/devops-lessons-microsoft.

Ancona, Deborah Gladstein, and David F. Caldwell. "Demography and Design: Predictors of New Product Team Performance." *Organization Science* 3 no. 3 (1992): 321–341. https://doi.org/10.1287/orsc.3.3.321.

Axelrod, Robert A. *Complexity of Cooperation: Agent-Based Models of Competition and Collaboration*. Princeton, NJ: Princeton University Press, 1997.

Bauernberger, Joachim. "DevOps in Telecoms—Is It Possible?" *Telecom Tech News*, October 1, 2014. http://www.telecomstechnews.com/news/2014/oct/01/devops-telecoms-it-possible/.

Beal, Helen. "The Industry Just Can't Decide about DevOps Teams." *InfoQ*, October 26, 2017. https://www.infoq.com/news/2017/10/devops-teams-good-or-bad.

Beer, Stafford. *Brain of the Firm*, 2nd edition. Chichester, UK: John Wiley & Sons, 1995.

Bennett, Drake. "The Dunbar Number, From the Guru of Social Networks." Bloomberg.com, January 11, 2013. http://www.bloomberg.com/news/articles/2013-01-10/the-dunbar-number-from-the-guru-of-social-networks.

Bernstein, Ethan, John Bunch, Niko Canner, and Michael Lee. "Beyond the Holacracy Hype." *Harvard Business Review*, July 1, 2016. https://hbr.org/2016/07/beyond-the-holacracy-hype.

Bernstein, Ethan, Jesse Shore, and David Lazer. "How Intermittent Breaks in Interaction Improve Collective Intelligence." *Proceedings of the National Academy of Sciences* 115 no. 35 (August, 2018): 8734–8739. https://doi.org/10.1073/pnas.1802407115.

Bernstein, Ethan S., and Stephen Turban. “The Impact of the ‘Open’ Workspace on Human Collaboration.” *Philosophical Transactions of the Royal Society B* 373 no. 1753 (2018). https://doi.org/10.1098/rstb.2017.0239.

Betz, Charles. *Managing Digital: Concepts and Practices*. The Open Group, 2018.

Beyer, Betsy, Jennifer Petoff, Chris Jones, and Niall Richard Murphy (eds). *Site Reliability Engineering: How Google Runs Production Systems*. Sebastopol, CA: O’Reilly, 2016.

Blalock, Micah. “Of Mustard Seeds and Microservices.” *Credera* (blog), May 6, 2015. https://www.credera.com/blog/technology-insights/java/mustard-seeds-microservices/.

Bosch, Jan. “On the Development of Software Product-Family Components.” In *Software Product Lines*, edited by Robert L. Nord, 146–164. Berlin: Springer, 2004.

Bottcher, Evan. “What I Talk About When I Talk About Platforms.” *MartinFowler.com* (blog), March 5, 2018. https://martinfowler.com/articles/talk-about-platforms.html.

Brandolini, Alberto. “Strategic Domain Driven Design with Context Mapping.” *InfoQ*, November 25, 2009. https://www.infoq.com/articles/ddd-contextmapping.

Bright, Peter. “How Microsoft Dragged Its Development Practices into the 21st Century.” *Ars Technica*, August 6, 2014. https://arstechnica.com/information-technology/2014/08/how-microsoft-dragged-its-development-practices-into-the-21st-century/.

Brooks, Fred. *The Mythical Man-Month: Essays on Software Engineering.* Boston, MA: Addison-Wesley, 1995.

Brown, Simon. “Are You a Software Architect?” *InfoQ*, February 9, 2010. https://www.infoq.com/articles/brown-are-you-a-software-architect.

Bryson, Brandon. “Architects Should Code: The Architect’s Misconception.” *InfoQ*, August 6, 2015. https://www.infoq.com/articles/architects-should-code-bryson.

Burgess, Mark. *Thinking in Promises: Designing Systems for Cooperation*. Sebastopol, CA: O’Reilly Media, 2015.

Carayon, Pascale. “Human Factors of Complex Sociotechnical Systems.” *Applied Ergonomics, Special Issue: Meeting Diversity in Ergonomics* 37 no. 4 (2006): 525–535. https://doi.org/10.1016/j.apergo.2006.04.011.

Casella, Karen. “Improving Team Productivity by Reducing Context Switching | LinkedIn.” *LinkedIn Pulse*, October 26, 2016. https://www.linkedin.com/pulse/improving-team-productivity-reducing-context-karen-casella/.

Chaudhary, Mukesh. “Working with Component Teams: How to Navigate the Complexity-Scrum Alliance.” ScrumAlliance.org, September 5, 2012. https://www.scrumalliance.org/community/member-articles/301.

Cherns, Albert. “The Principles of Sociotechnical Design.” *Human Relations* 29 no. 8 (1976): 783–792. https://doi.org/10.1177/001872677602900806.

Clegg, Chris W. “Sociotechnical Principles for System Design.” *Applied Ergonomics* 31 no. 5 (2000): 463–477. https://doi.org/10.1016/S0003-6870(00)00009-0.

Cockcroft, Adrian. “Goto Berlin—Migrating to Microservices (Fast Delivery).” Presented at the GOTO Berlin conference, Berlin, November 15, 2014. http://www.slideshare.net/adriancockcroft/goto-berlin.

Cohn, Mike. “Nine Questions To Assess Scrum Team Structure.” *Mountain Goat Software* (blog), March 9, 2010. https://www.mountaingoatsoftware.com/blog/nine-questions-to-assess-team-structure.

Conway, Melvin E. “How Do Committees Invent? Design Organization Criteria.” *Datamation*, 1968.

Conway, Mel. “Toward Simplifying Application Development, in a Dozen Lessons,” MelConway.com, January 3, 2017. http://melconway.com/Home/pdf/simplify.pdf.

Cooley, Faith. “Organizational Design for Effective Software Development.” SlideShare, posted by Dev9Com, November 12, 2014. http://www.slideshare.net/Dev9Com/organizational-design-for-effective-software-development.

Coplien, James O., and Neil Harrison. *Organizational Patterns of Agile Software Developmen*t. Upper Saddle River, NJ: Pearson Prentice Hall, 2005.

Cottmeyer, Mike. “Things to Consider When Structuring Your Agile Enterprise.” *LeadingAgile* (blog), February 5, 2014. https://www.leadingagile.com/2014/02/structure-agile-enterprise/.

Coutu, Diane. “Why Teams Don’t Work.” *Harvard Business Review*, May 1, 2009. https://hbr.org/2009/05/why-teams-dont-work.

Crawford, Jason. “Amazon’s ‘Two-Pizza Teams’: The Ultimate Divisional Organization.” *JasonCrawford.org* (blog), July 30, 2013. http://blog.jasoncrawford.org/two-pizza-teams.

Cunningham, Ward. “Understand the High Cost of Technical Debt by Ward Cunningham—DZone Agile.” Dzone.com, August 24, 2013. https://dzone.com/articles/understand-high-cost-technical.

Cusumano, Michael A. *Microsoft Secrets: How the World’s Most Powerful Software Company Creates Technology, Shapes Markets and Manages People*, 1st Touchstone edition. New York: Simon and Schuster, 1988.

Cutler, John. “12 Signs You’re Working in a Feature Factory.” *Hacker Noon*, November 17, 2016. https://hackernoon.com/12-signs-youre-working-in-a-feature-factory-44a5b938d6a2.

Davies, Rachel, and Liz Sedley. *Agile Coaching.* Raleigh, NC: Pragmatic Bookshelf, 2009.

DeGrandis, Dominica. *Making Work Visible: Exposing Time Theft to Optimize Workflow*. Portland, OR: IT Revolution Press, 2017.

DeMarco, Tom, and Timothy Lister. P*eopleware: Productive Projects and Teams*, 2nd revised edition. New York, NY: Dorset, 1999.

Deming, W. Edwards. *Out of the Crisis*. Cambridge, MA: MIT Press, 1986.

DeSanctis, Gerardine, and Marshall Scott Poole. “Capturing the Complexity in Advnaced Technology Use: Adaptive Structuration Theory.” *Organization Science 5* no. 2 (May 1994): 121–147.

Dogan, Jaana B. “The SRE Model.” *Medium*, July 31, 2017. https://medium.com/@rakyll/the-sre-model-6e19376ef986.

Doorley, Scott, and Scott Witthoft. *Make Space: How to Set the Stage for Create Collaboration*. Hoboken, NJ: John Wiley & Sons, 2012.

Driskell, James E., and Eduardo Salas. “Collective Behavior and Team Performance.” *Human Factors* 34 no. 3 (1992): 277–288. https://doi.org/10.1177/001872089203400303.

Driskell, James E., Eduardo Salas, and Joan Johnston. “Does Stress Lead to a Loss of Team Perspective?” Group Dynamics: *Theory, Research, and Practice* 3, no. 4 (1999): 291–302.

Drucker, Peter. *The Daily Drucker: 366 Days of Insight and Motivation for Getting the Right Things Done*. New York: HarperCollins, 2018.

Dunbar, R. I. M. “Neocortex Size as a Constraint on Group Size in Primates.” *Journal of Human Evolution* 22, no. 6 (1992): 469–493. https://doi.org/10.1016/0047-2484(92)90081-J.

Dunbar, Professor Robin. *How Many Friends Does One Person Need?: Dunbar's Number and Other Evolutionary Quirks*. London: Faber & Faber, 2010.

Eckstein, Jutta. *Agile Development in the Large: Diving into the Deep*. New York: Dorset, 2004.

Eckstein, Jutta. "Architecture in Large Scale Agile Development." In *Agile Methods. Large-Scale Development, Refactoring, Testing, and Estimation*, edited by Torgeir Dingsøyr, Nils Brede Moe, Roberto Tonelli, Steve Counsell, Cigdem Gencel, and Kai Petersen. Switzerland, Springer International Publishing, 2014.

Edmondson, Amy. "Psychological Safety and Learning Behavior in Work Teams." *Administrative Science Quarterly* 44 no. 2 (1999): 350–383. https://doi.org/10.2307/2666999.

Edmondson, Amy C. *Managing the Risk of Learning: Psychological Safety in Work Teams*. In *International Handbook of Organization Teamwork and Cooperative Working*, edited by Michael A. West, Dean Tjosvold, and Ken G. Smith. Hoboken, NJ: Wiley & Sons, 2003.

Edwards, Damon. "What is DevOps?" Dev2Ops.org, February 23, 2010. http://dev2ops.org g/2010/02/what-is-devops.

The Essential Elements of Enterprise PaaS. Palo Alto, CA: Pivotal, 2015. https://content.pivotal.io /white-papers/the-essential-elements-of-enterprise-paas.

Evans, Eric. *Domain-Driven Design: Tackling Complexity in the Heart of Software*. Boston, MA: Addison Wesley, 2003.

Evans, William. "The Need for Speed: Enabling DevOps through Enterprise Architecture | #DOES16." SlideShare, posted by William Evans, November 2, 2016. https://www.slideshare.net/willevans/the-need-for-speed-enabling-devops-through-enterprise-architecture.

Fan, Xiaocong, Po-Chun Chen, and John Yen. "Learning HMM-Based Cognitive Load Models for Supporting Human-Agent Teamwork." *Cognitive Systems Research* 11, no. 1 (2010): 108–119.

Feathers, Michael. *Working Effectively with Legacy Code*. Upper Saddle River, NJ: Prentice Hall, 2004.

Forrester, Russ, and Allan B. Drexler. "A Model for Team-Based Organization Performance." *The Academy of Management Executive* 13 no. 3 (1999), 36–49.

Forsgren, PhD, Nicole, Jez Humble, and Gene Kim. *Accelerate: The Science of Lean Software and Devops: Building and Scaling High Performing Technology Organizations*. Portland, Oregon: IT Revolution Press, 2018.

Fowler, Martin. "Bliki: BoundedContext." *MartinFowler.com* (blog), January 15, 2014. https://martinfowler.com/bliki/BoundedContext.html.

Fowler, Martin. "Bliki: MicroservicePrerequisites." *MartinFowler.com* (blog), August 28, 2014. https://martinfowler.com/bliki/MicroservicePrerequisites.html.

Fried, Jason, and David Heinemeir Hansson. *Remote: Office Not Required*. NY: Crown Business, 2013.

Gothelf, Jeff, and Josh Seiden. *Sense and Respond: How Successful Organizations Listen to Customers and Create New Products Continuously*. Boston, Massachusetts: Harvard Business Review Press, 2017.

Greenleaf, Robert K. *The Servant as Leader*, Revised Edition. Atlanta, GA: The Greenleaf Center for Servant Leadership, 2015.

"Guide: Understand Team Effectiveness." re:Work website, https://rework.withgoogle.com/guides /understanding-team-effectiveness/steps/define-team/.

Hall, Jon. “ITSM, DevOps, and Why Three-Tier Support Should Be Replaced with Swarming.” *Medium*, December 17, 2016. https://medium.com/@JonHall_/itsm-devops-and-why-the-three-tier-structure-must-be-replaced-with-swarming-91e76ba22304.

Hastie, Shane. “An Interview with Sam Guckenheimer on Microsoft’s Journey to Cloud Cadence.” *InfoQ*, October 17, 2014. https://www.infoq.com/articles/agile2014-guckenheimer.

HBS Communications. “Collaborate on Complex Problems, but Only Intermittently.” *Harvard Gazette* (blog), August 15, 2018. https://news.harvard.edu/gazette/story/2018/08/collaborate-on-complex-problems-but-only-intermittently/.

Helfand, Heidi Shetzer. *Dynamic Reteaming: The Art and Wisdom of Changing Teams*. Heidi Helfand, 2018.

Hoff, Todd. “Amazon Architecture.” *High Scalability* (blog), September 18, 2007. http://highscalability.com/blog/2007/9/18/amazon-architecture.html.

Holliday, Ben. “A ‘Service-Oriented’ Approach to Organisation Design.” *FutureGov* (blog), September 25, 2018. https://blog.wearefuturegov.com/a-service-oriented-approach-to-organisation-design-1e075be7f578.

Hoskins, Drew. “What Is It like to Be Part of the Infrastructure Team at Facebook?” *Quora*, last updated February 15, 2015. https://www.quora.com/What-is-it-like-to-be-part-of-the-Infrastructure-team-at-Facebook.

Humble, Jez. “There’s No Such Thing as a ‘Devops Team’.” *Continuous Delivery* (blog), October 19, 2012. https://continuousdelivery.com/2012/10/theres-no-such-thing-as-a-devops-team/.

Humble, Jez, and David Farley. *Continuous Delivery: Reliable Software Releases through Build, Test, and Deployment Automation*. Upper Saddle River, NJ: Addison Wesley, 2010.

Humble, Jez, Joanne Molesky, and Barry O’Reilly. *Lean Enterprise: How High Performance Organizations Innovate at Scale*. Sebastopol, CA: O’Reilly Media, 2015.

Ilgen, Daniel R., and John R. Hollenbeck. ‘Effective Team Performance under Stress and Normal Conditions: An Experimental Paradigm, Theory and Data for Studying Team Decision Making in Hierarchical Teams with Distributed Expertise’. DTIC Document, 1993. http://oai.dtic.mil/oai/oai?verb=getRecord&metadataPrefix=html&identifier=ADA284683.

Ingles, Paul. “Convergence to Kubernetes.” *Paul Ingles* (blog), June 18, 2018. https://medium.com/@pingles/convergence-to-kubernetes-137ffa7ea2bc.

innolution. n.d. “Feature Team Definition | Innolution.” Accessed October 14, 2018. https://innolution.com/resources/glossary/feature-team

“DevOps Over Coffee—Adidas.” YouTube video, 32:03, posted by IT Revolution, July 3, 2018. https://www.youtube.com/watch?v=oOjdXeGp44E&feature=youtu.be&t=1071.

Jang, Sujin. “Cultural Brokerage and Creative Performance in Multicultural Teams.” *Organization Science* 28 no. 6 (2017): 993–1009. https://doi.org/10.1287/orsc.2017.1162.

Jay, Graylin, Joanne Hale, Randy Smith, David Hale, Nicholas Kraft, and Charles Ward. “Cyclomatic Complexity and Lines of Code: Empirical Evidence of a Stable Linear Relationship.” *Journal of Software Engineering & Applications* 2 (January): 137–143. https://doi.org/10.4236/jsea.2009.23020.

John, Wolfgang. “DevOps for Service Providers—Next Generation Tools.” *Ericsson Research Blog.* December 7, 2015. https://www.ericsson.com/research-blog/cloud/devops-for-service-providers-next-generation-tools/.

Johnston, Joan H., Stephen M. Fiore, Carol Paris, and C. A. P. Smith. "Application of Cognitive Load Theory to Developing a Measure of Team Decision Efficiency." *Military Psychology* 3 (2003). https://www.tandfonline.com/doi/abs/10.1037/h0094967.

Karlgaard, Rich, and Michael S. Malone. *Team Genius: The New Science of High-Performing Organizations*. New York, NY: HarperBusiness, 2015.

Kelly, Allan. *Business Patterns for Software Developers*. Chichester, UK: John Wiley & Sons, 2012.

Kelly, Allan. "Conway's Law v. Software Architecture." Dzone.com (blog), March 14, 2013. https://dzone.com/articles/conways-law-v-software.

Kelly, Allan. "Conway's Law & Continuous Delivery." SlideShare, posted by Allen Kelly, April 9, 2014, https://www.slideshare.net/allankellynet/conways-law-continuous-delivery.

Kelly, Allan. "No Projects—Beyond Projects." *InfoQ*, December 5, 2014. https://www.infoq.com/articles/kelly-beyond-projects.

Kelly, Allan. *Project Myopia: Why Projects Damage Software #NoProjects*. Allan Kelly: 2018.

Kelly, Allan. "Return to Conway's Law." *Allan Kelly Associates* (blog), January 17, 2006. https://www.allankellyassociates.co.uk/archives/1169/return-to-conways-law/.

Kersten, Mik. *Project to Product: How to Survive and Thrive in the Age of Digital Disruption with the Flow Framework*. Portland, OR: IT Revolution Press, 2018.

Kim, Gene, Jez Humble, Patrick Debois, and John Willis. *The DevOps Handbook: How to Create World-Class Agility, Reliability, and Security in Technology Organizations*. Portland, OR: IT Revolution Press, 2016.

Kim, Dr. Kyung Hee, and Robert A. Pierce. "Convergent Versus Divergent Thinking." In *Encyclopedia of Creativity, Invention, Innovation and Entrepreneurship*, edited by Elias G. Carayannis, 245–250. New York: Springer, 2013.

Kitagawa, Justin. "Platforms at Twilio: Unlocking Developer Effectiveness." *InfoQ*, October 18, 2018. https://www.infoq.com/presentations/twilio-devops

Kitson, Jon. "Squad Health Checks." *Sky Betting & Gaming Technology* (blog), February 1, 2017. https://technology.skybettingandgaming.com/2017/02/01/squad-health-checks/.

Kniberg, Henrik, and Anders Ivarsson. "Scaling Agile @ Spotify with Tribes, Squads, Chapters & Guilds." *Crisp's Blog.* October 2012. https://blog.crisp.se/wp-content/uploads/2012/11/SpotifyScaling.pdf.

Kniberg, Henrik. "Real-Life Agile Scaling." Presented at the Agile Tour Bangkok, Thailand, November 21, 2015. http://blog.crisp.se/wp-content/uploads/2015/11/Real-life-agile-scaling.pdf.

Kniberg, Henrik. "Squad Health Check Model—Visualizing What to Improve." *Spotify Labs* (blog), September 16, 2014. https://labs.spotify.com/2014/09/16/squad-health-check-model/

Knight, Pamela. "Acquisition Community Team Dynamics: The Tuckman Model vs. the DAU Model." *Proceedings from the 4th Annual Acquisition Research Symposium of the Naval Postgraduate School* (2007). https://apps.dtic.mil/dtic/tr/fulltext/u2/a493549.pdf.

Kotter, John P. "Accelerate!" *Harvard Business Review*, November 1, 2012. https://hbr.org/2012/11/accelerate.

Kramer, Staci D. "The Biggest Thing Amazon Got Right: The Platform." *Gigaom*, October 12, 2011. https://gigaom.com/2011/10/12/419-the-biggest-thing-amazon-got-right-the-platform/.

Laloux, Frédéric. *Reinventing Organizations: An Illustrated Invitation to Join the Conversation on Next-Stage Organizations*. Oxford, UK: Nelson Parker, 2016.

Lane, Kim. “The Secret to Amazon’s Success—Internal APIs.” *API Evangelist* (blog), January 12, 2012.http://apievangelist.com/2012/01/12/the-secret-to-amazons-success-internal-apis/.

Larman, Craig, and Bas Vodde. “Choose Feature Teams over Component Teams for Agility.” *InfoQ*, July 15, 2008. https://www.infoq.com/articles/scaling-lean-agile-feature-teams.

Larman, Craig, and Bas Vodde. *Large-Scale Scrum: More with LeSS*. Upper Saddle River, NJ: Addison-Wesley Professional, 2016.

Leffingwell, Dean. “Feature Teams vs. Component Teams (Continued).” *Scaling Software Agility* (blog), May 2, 2011. https://scalingsoftwareagility.wordpress.com/2011/05/02/feature-teams-vs-component-teams-continued/.

Leffingwell, Dean. “Organizing at Scale: Feature Teams vs. Component Teams – Part 3.” *Scaling Software Agility* (blog), July 22, 2009. https://scalingsoftwareagility.wordpress.com/2009/07/22/organizing-agile-at-scale-feature-teams-versus-component-teams-part-3/.

Leffingwell, Dean. *Scaling Software Agility: Best Practices for Large Enterprises*. Upper Saddle River, NJ: Addison-Wesley Professional, 2007.

Lencioni, Patrick M. *The Five Dysfunctions of a Team: A Leadership Fable*. San Francisco, CA: John Wiley & Sons, 2002.

Leveson, Nancy G. *Engineering a Safer World: Systems Thinking Applied to Safety*. Cambridge, MA: MIT Press, 2017.

Levina, Natalia, and Emmanuelle Vaast. “The Emergence of Boundary Spanning Competence in Practice: Implications for Information Systems’ Implementation and Use.” *MIS Quarterly* 29 no. 2 (June 2005): 335–363. https://papers.ssrn.com/abstract=1276022.

Lewis, James. “Microservices and the Inverse Conway Manoeuvre—James Lewis.” YouTube video, 57:57, posted by NDC Conferences, February 16, 2017. https://www.youtube.com/watch?v=uamh7xppO3E.

Lim, Beng-Chong, and Katherine J. Klein. “Team Mental Models and Team Performance: A Field Study of the Effects of Team Mental Model Similarity and Accuracy.” *Journal of Organizational Behavior* 27, no. 4 (June 1, 2006): 403–418. https://doi.org/10.1002/job.387.

Linders, Ben. “Scaling Teams to Grow Effective Organizations.” *InfoQ*, August 11, 2016. https://www.infoq.com/news/2016/08/scaling-teams.

Long, Josh. “GARY (Go Ahead, Repeat Yourself).” Tweet @starbuxman, May 25, 2016. https://twitter.com/starbuxman/status/735550836147814400.

Lowe, Steven A. “How to Use Event Storming to Achieve Domain-Driven Design.” *TechBeacon*, October 15, 2015. https://techbeacon.com/introduction-event-storming-easy-way-achieve-domain-driven-design.

Luo, Jiao, Andrew H. Van de Ven, Runtian Jing, and Yuan Jiang. “Transitioning from a Hierarchical Product Organization to an Open Platform Organization: A Chinese Case Study.” *Journal of Organization Design* 7 (January): 1. https://doi.org/10.1186/s41469-017-0026-x.

MacCormack, Alan, John Rusnak, and Carliss Y. Baldwin. “Exploring the Structure of Complex Software Designs: An Empirical Study of Open Source and Proprietary Code.” *Management Science* 52, no. 7 (2006): 1015–1030. https://doi.org/10.1287/mnsc.1060.0552.

MacCormack, Alan, Carliss Y. Baldwin, and John Rusnak. “Exploring the Duality Between Product and Organizational Architectures: A Test of the ‘Mirroring’ Hypothesis.” *Research Policy* 41, no. 8 (October 2012): 1309–1024. http://www.hbs.edu/faculty/Pages/item.aspx?num=43260.

Malan, Ruth. "Conway's Law." *TraceintheSand.com* (blog), February 13, 2008. http://traceinthesand.com/blog/2008/02/13/conways-law/.

Manns, Mary Lynn, and Linda Rising, *Fearless Change: Patterns for Introducing New Ideas*. Boston, MA: Addison Wesley, 2004.

Marshall, Bob. "A Team Is Not a Group of People Who Work Together. A Team Is a Group of People Who Each Put the Team before Themselves." Tweet, @flowchainsensei, October 29, 2018. https://twitter.com/flowchainsensei/status/1056838136574152704.

McChrystal, General Stanley, David Silverman, Tantum Collins, and Chris Fussell. *Team of Teams: New Rules of Engagement for a Complex World*. New York, NY: Portfolio Penguin, 2015.

Meadows, Donella. *Leverage Points: Places to Intervene in a System*. Hartland, VT: Sustainability Institute, 1999. http://donellameadows.org/wp-content/userfiles/Leverage_Points.pdf.

"Microservices: Organizing Large Teams for Rapid Delivery." SlideShare, posted by Pivotal, August 10, 2016. https://www.slideshare.net/Pivotal/microservices-organizing-large-teams-for-rapid-delivery.

Mihaljov, Timo. "Having a Dedicated DevOps Person Who Does All the DevOpsing Is like Having a Dedicated Collaboration Person Who Does All the Collaborating." Tweet. @noidi. April 14, 2017. https://twitter.com/noidi/status/852879869998501889.

Miller, G. A. "The Magical Number Seven, Plus or Minus Two: Some Limits on Our Capacity for Processing Information." *Psychological Review* 63 no. 2 (1956): 81–97.

Minick, Eric. "The Goal for a 'DevOps Team' Should Be to Put Itself out of Business by Enabling the Rest of the Org." Tweet, @ericminick, October 8, 2014. https://twitter.com/ericminick/status/517335119330172930.

Minick, Eric, and Curtis Yanko. "Creating a DevOps Team That Isn't Evil." SlideShare, posted by IBM Urban Code Products, March 5, 2015. http://www.slideshare.net/Urbancode/creating-a-devops-team-that-isnt-evil.

Mole, David. "Drive: How We Used Daniel Pink's Work to Create a Happier, More Productive Work Place." *InfoQ*, September 10, 2015. https://www.infoq.com/articles/drive-productive-workplace.

Morgan-Smith, Victoria, and Matthew Skelton. *Internal Tech Conferences*. Leeds, UK: Conflux Digital, 2019.

Morris, Kief. *Infrastructure as Code: Managing Servers in the Cloud*. Sebastopol, CA: O'Reilly Media, 2016.

Munns, Chris. "Chris Munns, DevOps @ Amazon: Microservices, 2 Pizza Teams, & 50 Million Deploys per Year." SlideShare.net, posted by TriNimbus, May 6, 2016. http://www.slideshare.net/TriNimbus/chris-munns-devops-amazon-microservices-2-pizza-teams-50-million-deploys-a-year.

Murphy, Niall. "What is 'Site Reliability Engineering'?" Landing.Google.com, https://landing.google.com/sre/interview/ben-treynor.html.

Murphy, Niall and Ben Treynor. "What is 'Site Reliability Engineering'?" Landing.Google.com (blog), accessed March 21, 2019. https://landing.google.com/sre/interview/ben-treynor.html.

Narayan, Sriram. *Agile IT Organization Design: For Digital Transformation and Continuous Delivery*. New York: Addison-Wesley Professional, 2015.

Neumark, Peter. "DevOps & Product Teams—Win or Fail?" *InfoQ*, June 29, 2015. https://www.infoq.com/articles/devops-product-teams.

Netflix Technology Blog. "Full Cycle Developers at Netflix—Operate What You Build." *Medium.com*, May 17, 2018, https://medium.com/netflix-techblog/full-cycle-developers-at-netflix-a08c31f83249.

Netflix Technology Blog. "The Netflix Simian Army." Netflix TechBlog, July 19, 2011. https://medium.com/netflix-techblog/the-netflix-simian-army-16e57fbab116.

Newman, Sam. *Building Microservices: Design Fine-Grained Systems*. Sebastopol, CA: O'Reilly Media, 2015.

Newman, Sam. "Demystifying Conway's Law." ThoughtWorks (blog) June 30, 2014. https://www.thoughtworks.com/insights/blog/demystifying-conways-law.

Nygard, Michael. "The Perils of Semantic Coupling—Wide Awake Developers." MichaelNygard.com (blog), April 29, 2015. http://michaelnygard.com/blog/2015/04/the-perils-of-semantic-coupling/.

Nygard, Michael T. *Release It! Design and Deploy Production-Ready Software*, 2nd edition. Raleigh, North Carolina: O'Reilly, 2018.

O'Connor, Debra L., and Tristan E. Johnson. "Understanding Team Cognition in Performance Improvement Teams: A Meta-Analysis of Change in Shared Mental Models." *Proceedings of the Second International Conference on Concept Mapping* (2006). https://pdfs.semanticscholar.org/4106/3eb1567e630a35b4f33f281a6bb9d193ddf5.pdf.

O'Dell, Chris. "You Build It, You Run It (Why Developers Should Also Be on Call)." Skelton Thatcher.com (blog), October 18, 2017. https://skeltonthatcher.com/blog/build-run-developers-also-call/.

Overeem, Barry. "How I Used the Spotify Squad Health Check Model—Barry Overeem—The Liberators." BarryOvereem.com (blog), August 7, 2015. http://www.barryovereem.com/how-i-used-the-spotify-squad-health-check-model/.

Pais, Manuel. "Damon Edwards: DevOps is an Enterprise Concern" *InfoQ*, May 31, 2014. https://www.infoq.com/interviews/interview-damon-edwards-qcon-2014.

Pais, Manuel. "Prezi's CTO on How to Remain a Lean Startup after 4 Years." *InfoQ*, October 5, 2012. https://www.infoq.com/news/2012/10/Prezi-lean-startup.

Pais, Manuel, and Matthew Skelton. "The Divisive Effect of Separate Issue Tracking Tools." *InfoQ*, March 22, 2017. https://www.infoq.com/articles/issue-tracking-tools.

Pais, Manuel, and Matthew Skelton. "Why and How to Test Logging." *InfoQ*, October 29, 2016. https://www.infoq.com/articles/why-test-logging.

Pearce, Jo. "Day 3: Managing Cognitive Load for Team Learning." *12 Devs of Xmas* (blog), December 28, 2015. http://12devsofxmas.co.uk/2015/12/day-3-managing-cognitive-load-for-team-learning/.

Pearce, Jo. "Hacking Your Head : Managing Information Overload (Extended)." SlideShare, posted by Jo Pearce, April 29, 2016. https://www.slideshare.net/JoPearce5/hacking-your-head-managing-information-overload-extended.

Perri, Melissa. *Escaping the Build Trap: How Effective Product Management Creates Real Valu*e. Sebastopol, CA: O'Reilly, 2018.

Pflaeging, Niels. *Organize for Complexity: How to Get Life Back Into Work to Build the High-Performance Organization*, 1st edition. Germany: BetaCodex Publishing, 2014.

Pflaeging, Niels. "Org Physics: The 3 Faces of Every Company." *Niels Pflaeging* (blog), March 6, 2017. https://medium.com/@NielsPflaeging/org-physics-the-3-faces-of-every-company-df16025f65f8.

Phillips, Amy. "Testing Observability." *InfoQ*, April 5, 2018. https://www.infoq.com/presentations/observability-testing.

Pink, Daniel. *Drive: The Surprising Truth About What Motivates Us*. New York: Riverhead Books, 2009.

Raymond, Eric. *The New Hacker's Dictionary*, 3rd Edition. Boston, MA: MIT Press, 1996.

Reed, J. Paul. "Blameless Postmortems Don't Work. Be Blame-Aware but Don't Go Negative." *TechBeacon*, March 22, 2016. https://techbeacon.com/blameless-postmortems-dont-work-heres-what-does.

Reinertsen, Donald. *The Principles of Product Development Flow: Second Generation Lean Product Development*. Redondo Beach, CA: Celeritas Publishing, 2009.

Rensin, Dave. "Introducing Google Customer Reliability Engineering." Google Cloud Blog, October 10, 2016. https://cloud.google.com/blog/products/gcp/introducing-a-new-era-of-customer-support-google-customer-reliability-engineering/.

Roberts, John. *The Modern Firm: Organizational Design for Performance and Growth*. Oxford: Oxford University Press, 2007.

Robertson, Brian J. *Holocracy: The New Management System for a Rapidly Changing World*. NY: Henry Holt, 2015.

Rock, David, and Heidi Grant. *Why Diverse Teams Are Smarter*. Cambridge, MA: Harvard Business Review, 2016.

Rother, Mike. *Toyota Kata: Managing People for Improvement, Adaptiveness and Superior Results*. New York: McGraw-Hill Education, 2009.

Rozovsky, Julia. "Re:Work—The Five Keys to a Successful Google Team." re:Work (blog), November 17, 2015. https://rework.withgoogle.com/blog/five-keys-to-a-successful-google-team/.

Rubin, Kenneth S. *Essential Scrum: A Practical Guide to the Most Popular Agile Process*. Upper Saddle River, NJ: Addison Wesley, 2012.

Rummler, Geary, and Alan Brache. *Improving Performance: How to Manage the White Space on the Organization Chart*, 3rd edition. San Francisco, CA: Jossey-Bass, 2013.

Salas, Eduardo, and Stephen M. Fiore, eds. *Team Cognition: Understanding the Factors That Drive Process and Performance*. Washington, DC: American Psychological Association, 2004.

Scholtes, Ingo, Pavlin Mavrodiev, and Frank Schweitzer. "From Aristotle to Ringelmann: A Large-Scale Analysis of Team Productivity and Coordination in Open Source Software Projects." *Empirical Software Engineering* 21 no. 2 (2016): 642–683. https://doi.org/10.1007/s10664-015-9406-4.

Schotkamp, Tom, and Martin Danoesastro. "HR's Pioneering Role in Agile at ING." *BCG* (blog), June 1, 2018. https://www.bcg.com/en-gb/publications/2018/human-resources-pioneering-role-agile-ing.aspx.

Schwartz, Mark, Jason Cox, Jonathan Snyder, Mark Rendell, Chivas Nambiar, and Mustafa Kapadia. *Thinking Environments: Evaluating Organization Models for DevOps to Accelerate*. Portland, OR: IT Revolution Press, 2016.

Seiter, Courtney. "We've Changed Our Product Team Structure 4 Times: Here's Where We Are Today." *Buffer* (blog), October 20, 2015. https://open.buffer.com/product-team-evolution/.

Shibata, Kenichi. "How to Build a Platform Team Now! The Secrets to Successful Engineering." *Hacker Noon* (blog), September 29, 2018. https://hackernoon.com/how-to-build-a-platform-team-now-the-secrets-to-successful-engineering-8a9b6a4d2c8.

Simenon, Stefan, and Wiebe de Roos. "Transforming CI/CD at ABN AMRO to Accelerate Software Delivery and Improve Security." SlideShare, posted by DevOps.com, March 27, 2018. https://www.slideshare.net/DevOpsWebinars/transforming-cicd-at-abn-amro-to-accelerate-software-delivery-and-improve-security.

Sinha, Harsh. "Harsh Sinha on Building Culture at TransferWise." *InfoQ*, February 19, 2018. https://www.infoq.com/podcasts/Harsh-Sinha-transferwise-building-culture.

Skelton, Matthew. "How Different Team Topologies Influence DevOps Culture." *InfoQ*, September 2, 2015. https://www.infoq.com/articles/devops-team-topologies.

Skelton, Matthew. "How to Find the Right DevOps Tools for Your Team." *TechBeacon*, 2018. https://techbeacon.com/how-find-right-devops-tools-your-team.

Skelton, Matthew. "Icebreaker for Agile Retrospectives—Empathy Snap." MatthewSkelton.net (blog), November 15, 2012. http://empathysnap.com/.

Skelton, Matthew. *Tech Talks for Beginners*. Leeds, UK: Conflux Digital, 2018.

Skelton, Matthew. "What Team Structure Is Right for DevOps to Flourish?" MatthewSkelton.net (blog), October 22, 2013. https://blog.matthewskelton.net/2013/10/22/what-team-structure-is-right-for-devops-to-flourish/.

Skelton, Matthew. "Your Team's API Includes: - Code: REST Endpoints, Libraries, Clients, UI, Etc.—Wiki / Docs—Especially 'How To' Guides—Your Approach to Team Chat Tools (Slack /Hipchat)—Anything Else Which Other Teams Need to Use to Interact with Your Team It's Not Just about Code. #DevEx." Tweet, @matthewpskelton, July 25, 2018. https://twitter.com/matthewpskelton/status/1022111880423395329.

Skelton, Matthew, and Rob Thatcher. *Team Guide to Software Operability*. Leeds, UK: Conflux Books, 2016.

Skulmowski, Alexander, and Rey, Günter Daniel. "Measuring Cognitive Load in Embodied Learning Settings." *Frontiers in Psychology* 8 (August 2, 2017). https://doi.org/10.3389/fpsyg.2017.01191.

Smith, Steve, and Matthew Skelton, eds. *Build Quality In*. Leeds, UK: Conflux Digital, 2015.

Snowden, Dave. "The Rule of 5, 15 & 150." Cognitive Edge (blog), December 10, 2006. http://cognitive-edge.com/blog/logn-0-093-3-389-logcr-1-r20-764-t3410-35-p0-001/.

Sosa, Manuel E., Steven D. Eppinger, and Craig M. Rowles. "The Misalignment of Product Architecture and Organizational Structure in Complex Product Development." *Management Science* 50 no. 12 (December 2004): 1674–1689.

Stanford, Naomi. *Guide to Organisation Design: Creating High-Performing and Adaptable Enterprises (Economist Books)*, 2nd Edition. London: Economist Books, 2015.

Stompff, Guido. "Facilitating Team Cognition: How Designers Mirror What NPD Teams Do." *ResearchGate*, September 2012. https://www.researchgate.net/publication/254831689_Facilitating_Team_Cognition_How_designers_mirror_what_NPD_teams_do.

Strode, Diane E., Sid L. Huff, Beverley Hope, and Sebastian Link. "Coordination in Co-Located Agile Software Development Projects." J*ournal of Systems and Software, Special Issue: Agile Development* 85, no. 6 (June 1, 2012): 1222–38. https://doi.org/10.1016/j.jss.2012.02.017.

Sussna, Jeff. *Designing Delivery: Rethinking IT in the Digital Service Economy*. Sebastopol, CA: O'Reilly Media, 2015.

Sweller, John. "Cognitive Load During Problem Solving: Effects on Learning." *Cognitive Science* 12 no. 2 (1988): 257–285.

Sweller, John. "Cognitive Load Theory, Learning Difficulty, and Instructional Design." *Learning and Instruction* 4 (1994): 295–312.

"System Team." Scaled Agile Framework website, last updated October 5, 2018. https://www.scaledagileframework.com/system-team/.

Tuckman, Bruce W. "Developmental Sequence in Small Groups." *Psychological Bulletin* 63 no. 6 (1965): 384–399. https://doi.org/10.1037/h0022100.

Tune, Nick. "Domain-Driven Architecture Diagrams." *Nick Tune's Tech Strategy Blog*, August 15, 2015. https://medium.com/nick-tune-tech-strategy-blog/domain-driven-architecture-diagrams-139a75acb578.

Tune, Nick, and Scott Millett. *Designing Autonomous Teams and Services*. Sebastopol, CA: O'Reilly Media, 2017.

Urquhart, James. "Communications and Conway's Law." *Digital Anatomy* (blog), September 28, 2016. https://medium.com/digital-anatomy/communications-and-conways-law-6a1a9deae32.

Urquhart, James. "IT Operations in a Cloudy World." *CNET*, September 15, 2010. https://www.cnet.com/news/it-operations-in-a-cloudy-world/.

Wardley, Simon. "An Introduction to Wardley 'Value Chain' Mapping." *CIO UK*, March 19, 2015. https://www.cio.co.uk/it-strategy/introduction-wardley-value-chain-mapping-3604565/.

Wastell, Katherine. "What We Mean When We Talk about Service Design at the Co-Op." Co-Op Digital Blog, October 25, 2018. https://digitalblog.coop.co.uk/2018/10/25/what-we-mean-when-we-talk-about-service-design-at-the-co-op/.

Webber, Emily. *Building Successful Communities of Practice*. San Francisco, CA: Blurb, 2018.

Weinberg, Gerald M. *An Introduction to General Systems Thinking, 25th Silver Anniversary Edition*. New York: Dorset, 2001.

Wiener, Norbert. C*ybernetics: Or Control and Communication in the Animal and the Machin*e, 2nd edition. Cambridge, Mass: MIT Press, 1961.

Westrum, R. 2004. "A Typology of Organisational Cultures." *Quality & Safety in Health Care* 13 Suppl. 2 (1961): ii22–27. https://doi.org/10.1136/qshc.2003.009522.

"What Team Structure is Right for DevOps to Flourish?" DevOpsTopologies.com, accessed March 21, 2019. http://web.devopstopologies.com.

Wiley, Evan. "Scaling XP Through Self-Similarity at Pivotal Cloud Foundry." *Agile Alliance* (blog), July 28, 2018. https://www.agilealliance.org/resources/experience-reports/scaling-xp-through-self-similarity-at-pivotal-cloud-foundry/.

Womack, James P., and Daniel T. Jones. *Lean Thinking: Banish Waste and Create Wealth In Your Corporation*. NY: Simon & Schuster/Free Press, 2003.

Zambonelli, Franco. "Toward Sociotechnical Urban Superorganisms." *Computer*, 2012. http://spartan.ac.brocku.ca/~tkennedy/COMM/Zambonelli2012.pdf.

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3. Pflaeging, *Organize for Complexity*.
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6. Conway, "How do Committees Invent?, 31.
7. Conway, "How do Committees Invent?"; Kelly, "Conway's Law & Continuous Delivery."
8. Kelly, "Conway's Law v. Software Architecture."
9. Raymond, *The New Hacker's Dictionary*, 124.
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1. "DevOps Over Coffee – Adidas;" Fernando Cornago, person email communication with the authors, March 2019.
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8. MacCormack et al., "Exploring the Structure of Complex Software Designs."
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9. Ben Treynor, as quoted in Niall Murphy, “What is ‘Site Reliability Engineering’?”
10. Dogan, “The SRE Model.”
11. Rensin, “Introducing Google Customer Reliability Engineering.”
12. Netflix Technology Blog, “Full Cycle Developers at Netflix—Operate What You Build.”
13. DeGrandis, *Making Work Visible*, 82.
14. Strode and Huff, “A Taxonomy of Dependencies in Agile Software Development.”
15. Pulak Agrawal, personal communication with the authors, March 2019.
16. Pulak Agrawal, personal communication with the authors, March 2019.

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4. Crawford, At opening quotes. "Amazon's 'Two-Pizza Teams.'"
5. Dunbar, "Neocortex Size as a Constraint on Group Size in Primates," 469–493.
6. Snowden, "The Rule of 5, 15 & 150;" Dunbar, *How Many Friends Does One Person Need?*; Bennett, "The Dunbar Number, From the Guru of Social Networks;" Burgess, *Thinking in Promises*, 87.
7. Snowden, "The Rule of 5, 15 & 150;" Karlgaard and Malone, *Team Genius*, 201–205.
8. Lewis, "Microservices and the Inverse Conway Manoeuvre."
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10. Brooks, *The Mythical Man-Month*.
11. Tuckman, "Developmental Sequence in Small Groups," 384–399.
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16. Driskell and Salas, "Collective Behavior and Team Performance;" Rock and Grant, *Why Diverse Teams Are Smarter*.
17. Jang, "Cultural Brokerage and Creative Performance in Multicultural Teams," 993–1009; Carayon, "Human Factors of Complex Sociotechnical Systems," 525–535.
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28. Evan Wiley, as quoted in Helfand, *Dynamic Reteaming*, 121.
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35. Doorley and Witthoft, *Make Space*, 16.
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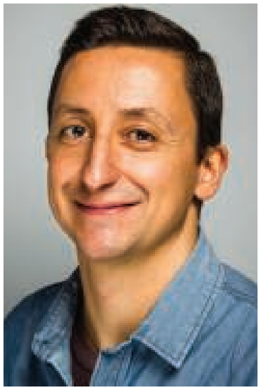

Matthew and **Manuel** have worked together on organization design for modern software systems with many clients around the world. Their training sessions on organization design for modern software systems have helped numerous organizations to rethink their approach to team intercommunication and software architecture, improving flow and the effectiveness of software delivery.