

## CHAPTER 9



# Application Development

Practically all use of databases occurs from within application programs. Correspondingly, almost all user interaction with databases is indirect, via application programs. In this chapter, we study tools and technologies that are used to build applications, focusing on interactive applications that use databases to store and retrieve data.

A key requirement for any user-centric application is a good user interface. The two most common types of user interfaces today for database-backed applications are the web and mobile app interfaces.

In the initial part of this chapter, we provide an introduction to application programs and user interfaces (Section 9.1), and to web technologies (Section 9.2). We then discuss development of web applications using the widely used Java Servlets technology at the back end (Section 9.3), and using other frameworks (Section 9.4). Client-side code implemented using JavaScript or mobile app technologies is crucial for building responsive user interfaces, and we discuss some of these technologies (Section 9.5). We then provide an overview of web application architectures (Section 9.6) and cover performance issues in building large web applications (Section 9.7). Finally, we discuss issues in application security that are key to making applications resilient to attacks (Section 9.8), and encryption and its use in applications (Section 9.9).

### Bibliographical Notes

The HTML tutorials at [www.w3schools.com/html](http://www.w3schools.com/html), the CSS tutorials at [www.w3schools.com/css](http://www.w3schools.com/css) are good resources for learning HTML and CSS. A tutorial on Java Servlets can be found at [docs.oracle.com/javaee/7/tutorial/servlets.htm](http://docs.oracle.com/javaee/7/tutorial/servlets.htm). The JavaScript tutorials at [www.w3schools.com/js](http://www.w3schools.com/js) are an excellent source of learning material on JavaScript. You can also learn more about JSON and Ajax as part of the JavaScript tutorial. The jQuery tutorial at [www.w3schools.com/Jquery](http://www.w3schools.com/Jquery) is a very good resource for learning how to use jQuery. These tutorials allow you to modify sample code and test it in the browser, with no software download. Information about the .NET framework and about web application development using ASP.NET can be found at [msdn.microsoft.com](http://msdn.microsoft.com).

You can learn more about the Hibernate ORM and Django (including the Django ORM) from the tutorials and documentation at [hibernate.org/orm](http://hibernate.org/orm) and [docs.djangoproject.com](http://docs.djangoproject.com) respectively.

The Open Web Application Security Project (OWASP) ([www.owasp.org](http://www.owasp.org)) provides a variety of technical material such as the OWASP Testing Guide, the OWASP Top Ten document which describes critical security risks, and standards for application security verification.

The concepts behind cryptographic hash functions and public-key encryption were introduced in [Diffie and Hellman (1976)] and [Rivest et al. (1978)]. A good reference for cryptography is [Katz and Lindell (2014)], while [Stallings (2017)] provides textbook coverage of cryptography and network security.

The asynchronous Web applications Ajax is described in [Holdener (2008)]

## Bibliography

- [Diffie and Hellman (1976)] W. Diffie and M. E. Hellman, “New Directions in Cryptography”, *IEEE Transactions on Information Theory*, Volume 22, Number 6 (1976).
- [Holdener (2008)] A. Holdener, *Ajax: The Definitive Guide*, O’reilly (2008).
- [Katz and Lindell (2014)] J. Katz and Y. Lindell, *Introduction to Modern Cryptography*, 3rd edition, Chapman and Hall/CRC (2014).
- [Rivest et al. (1978)] R. L. Rivest, A. Shamir, and L. Adleman, “A Method for Obtaining Digital Signatures and Public-Key Cryptosystems”, *Communications of the ACM*, Volume 21, Number 2 (1978), pages 120–126.
- [Stallings (2017)] W. Stallings, *Cryptography and Network Security - Principles and Practice*, 7th edition, Pearson (2017).