Health Study Support System Using Windows 8 Tablets—Tohoku Medical Megabank Organization Case Study—

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The Tohoku Medical Megabank Organization (ToMMo) established by Tohoku University, Japan, is conducting a longitudinal study of the health of residents in the areas affected by the Great East Japan Earthquake. The aim is to support reconstruction efforts by restoring community medical systems. Fujitsu is contributing to this project through its development of a system for Windows 8 tablets that presently supports seven health testing applications: a basic examination, an eye examination, a color vision test, a dental examination, a dental questionnaire, a clinical psychology examination, and a cognitive psychology examination. This health study support system, developed as a Web application, leverages Fujitsu's know-how in Web system development and facilitates accessibility and usability. It is designed to run health testing applications that are on a Windows Store application form. The system supports the ToMMo study in various ways, such as by improving the accuracy of the test results, enabling collection of data with a higher level of sophistication, reducing the time needed to digitize the test results, and simplifying test implementation. This means that human resources can be more efficiently deployed in comparison with conventional paper-based methodologies. This paper first describes the common structure of the health testing applications and then explains their key features.

1. Introduction

On March 11, 2011, a massive earthquake and tsunami devastated Japan's Tohoku region and Pacific coast. The Tohoku Medical Megabank Organization (ToMMo) was established by Tohoku University to build futuristic medical services that will help the region recover from the disaster through innovative recovery efforts.[1] The three primary activities of ToMMo are the construction and analysis of large-scale biobanks, the restoration of medical services in the aftermath of the 2011 Tohoku earthquake and tsunami, and the training of advanced medical specialists. One biobank-related project is a longitudinal health study.[2] There are concerns that residents of the disaster area not only suffered immediate harm when the earthquake and tsunami occurred but that they will also continue to suffer long-term effects such as post-traumatic stress reactions (PTSRs) and infections. Through regular medical examinations in the disaster area, the longitudinal health study is intended to assist with the early detection and medical care of such diseases.[3]

To support the longitudinal health study, Fujitsu has developed a system that runs on Fujitsu Windows 8 tablets and presently supports seven health testing applications that are on a Windows Store application form.

1) Basic examination
2) Eye examination
3) Color vision test
4) Dental examination
5) Dental questionnaire
6) Clinical psychological examination
7) Cognitive psychological examination

Health tests using these applications are being administered in regional support centers across Miyagi prefecture. People seeking medical examinations go to these centers and are tested using tablets and ordinary medical equipment under the supervision of a genome medical research coordinator (GMRC), doctor, and dentist.

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This paper first describes the common structure and characteristics of these health testing applications and then describes their key features.

2. Common structure and characteristics of applications

Each of the health testing applications runs on ToMMo's intranet, which is isolated from the Internet and has the following basic structure, as shown in **Figure 1.**

1) Health testing applications

The health testing applications encrypt the data they collect and have the following characteristics.

- An optimized platform that takes full advantage of touchscreen input and other areas in which tablets excel
- An immersive screen design so that users are absorbed in the Windows Store application (app) itself
- A flexible development platform based on hypertext markup language (HTML), cascading style sheet (CSS) language, and other Web development technologies supported by Windows Store apps that supports many different programming languages
- Accessibility support for patients of various ages using flexible user interfaces (UIs), such as that stipulated by the Japanese Standards Association in JIS X 8341-3[note)]
- Support for reading one-dimensional barcodes using the tablet's built-in camera or an attached USB barcode reader, enabling apps to read a patient's ID from the reception ticket
- A protected system environment in which the operating system (OS) and other parts of the system environment are reset when the tablet is restarted
- Biometric security using the tablet's built-in fingerprint sensor, ensuring that only authorized GMRCs, doctors, and dentists can log into the system

2) Data integration system

The encrypted data that is accumulated on a tablet is extracted, decrypted, and registered with the base system.

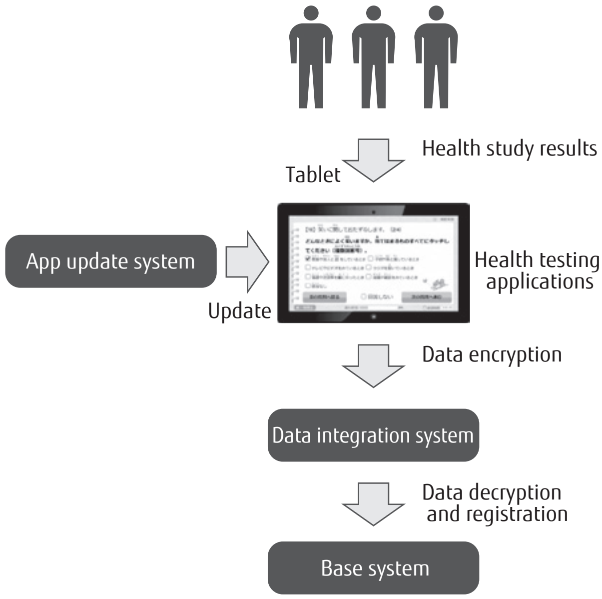

Figure 1
Basic structure of health study support system.

3) Base system

The base system stores not only the examination results collected by the various health testing applications but also data from ordinary medical equipment.

4) Application update system

The applications can be updated at an appropriate time for the particular regional support center. Unlike ordinary Windows Store apps, for which the updates are distributed from the Store, the health testing applications must be independently sideloaded because they can be used only on ToMMo's intranet. We considered using Microsoft System Center for sideloading the applications but ultimately developed our own system using PowerShell because it was difficult to remove features protecting the system environment and handle other issues with Microsoft System Center. This also enabled us to stop the system protection feature, update applications, restart the system protection feature, and otherwise control the system. We also built a dedicated active directory domain for sideloading the applications.

3. Key features of applications

The health testing applications were developed in coordination with specialists in each of the related medical fields at ToMMo. A working group of these

note) Guidelines for older persons and persons with disabilities - Information and communications equipment, software and services - Part 3: Web content specialists and the system developers convened for weekly progress reviews.

Members of the ToMMo Development Team:

- Tablet system coordination:
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- Basic examination:
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- Eye examination and color vision test:
  Nobuo Fuse, Kei Homma
- Dental examination and questionnaire:
  Akito Tsuboi, Naru Shiraishi
- Clinical psychological examination:
  Hiroaki Tomita, Kotomi Shingu, Tomoko Kitada, Tomoka Shoji
- Cognitive psychological examination:
  Yasuyuki Taki, Atsushi Sekiguchi, Daisuke Suzuki, Shoko Tsuzuki, Takayuki Nozawa

Four of the health testing applications are run by the patient: 1) basic examination, 2) eye examination, 3) color vision test, and 5) dental questionnaire. They were thus designed with simple screen layouts with an emphasis on accessibility by (for example) making text more legible and on usability by (for example) providing phonetic reading aids (*rubi*) for *kanji* characters. Furthermore, validation tests were run on the examination results from both dedicated medical equipment and the applications used for eye examinations and color vision tests to ensure a sufficient level of accuracy.

1) Basic examination

The basic examination was implemented as a health survey comprising 100 questions in 10 categories. An example screen is shown in **Figure 2 (a)**.

2) Eye examination

Unlike an ordinary eye examination, the eye examination application tests eyesight at short distances. As shown in **Figure 2 (b)**, a Landolt C is displayed on the screen at the appropriate size for the visual acuity being tested, with its gap pointing in a random direction. The examinee is then asked to tap the onscreen arrow that is pointing in the same direction as the gap. Examinees are given a chance to familiarize themselves with the application through practice screens to minimize the effect of a patient's unfamiliarity with the application on the test results.

3) Color vision test

The color vision test is equivalent to the "Panel D-15" color vision test. In this test, the examinee is asked to arrange 15 scattered panels with different colors in order of similarity to the color of the panel at the far left. Comparing the order in which the examinee places the panels with the correct order enables the type and severity of the examinee's color blindness (if any) to be determined. As with the eye examination, practice screens are provided. However, because the controls are more complex, if the gap between the examinee's ordering of the panels and the correct ordering is more than a certain level, the examinee is asked to repeat the test. This—to the greatest extent possible—prevents inexperience with the application from affecting the test results.

4) Dental examination

As shown in **Figure 2 (c)**, the dental examination provides a UI for registering the results of a dental examination, including the number of decayed, missing, and filled (DMF) teeth, the gingival index (bleeding index), and the extent of periodontal support, i.e., the clinical attachment level (CAL). It can even show or hide primary teeth and wisdom teeth as appropriate for the patient's age, making data entry more efficient.

5) Dental questionnaire

The dental questionnaire comprises about ten questions that are selected in accordance with the examinee's age. An example screen is shown in **Figure 2 (d)**.

6) Clinical psychology examination

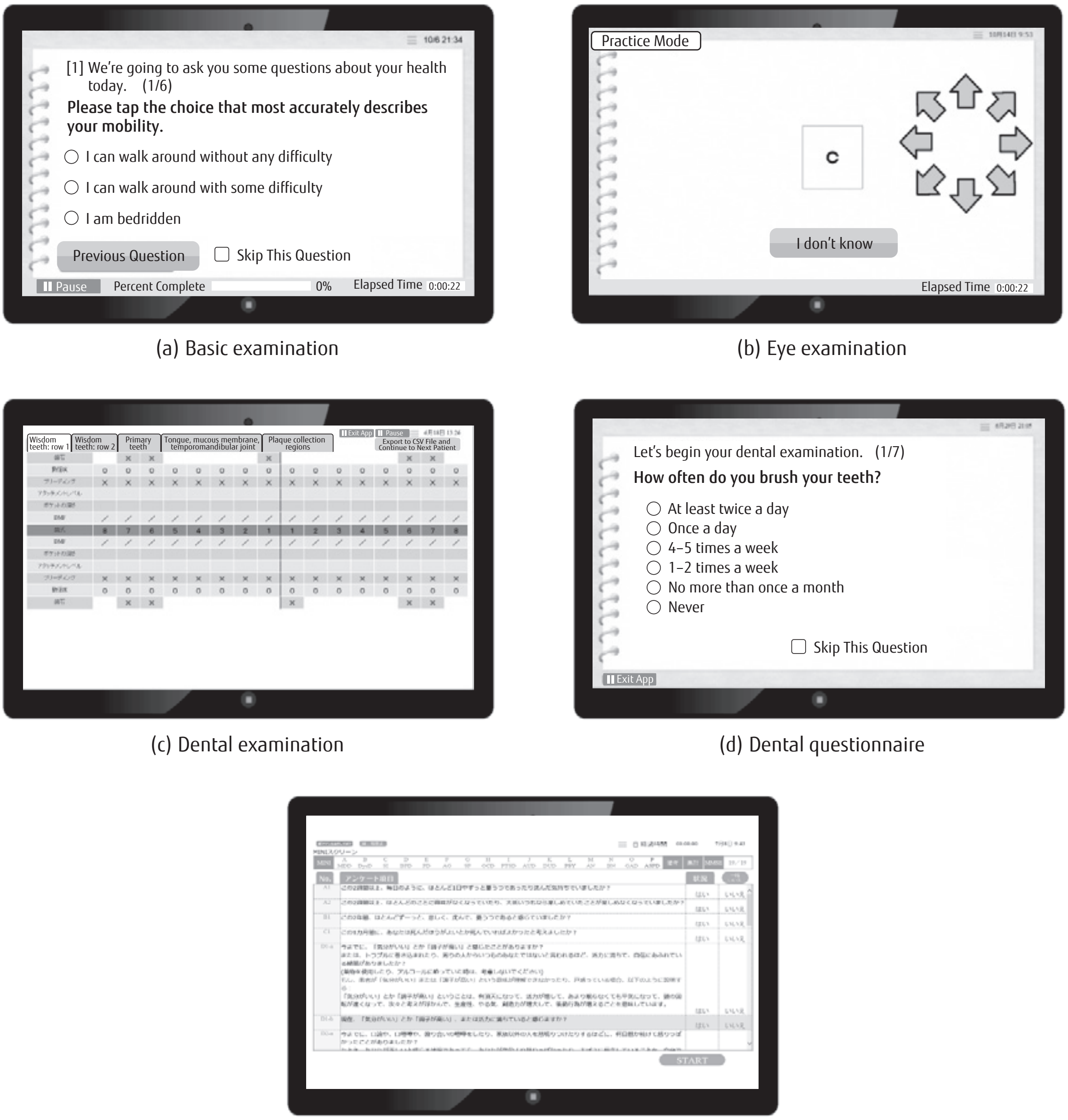
The clinical psychological examination comprises a set of questions administered to an examinee by a clinical psychologist. The psychologist selects the questions to ask on the basis of the examinee's responses and facial expressions. An example screen is shown in **Figure 2 (e)**.

7) Cognitive psychological examination

The cognitive psychological examination covers cognitive tasks such as pulse detection, decision-making tasks such as rational decision-making, and cognitive functions such as counteracting interference.

- Cognitive task: pulse detection

In this test, a pulse wave monitor is connected to a tablet via a USB connector to measure the examinee's pulse rate. The examinee measures his or her pulse rate subjectively for periods of 25, 35, and 45 seconds,



(a) Basic examination

(b) Eye examination

(c) Dental examination

(d) Dental questionnaire

(e) Clinical psychology examination

Figure 2
Example screens for five health testing applications (shown in English although the applications are currently only in Japanese).

and then the differences from the examinee's actual pulse rates (measured separately) are calculated. The average calculated difference is used as an index of the examinee's perception of his or her internal state.

- Decision-making task: rational decision-making

In this test, examinees are asked whether they would buy a lottery ticket for *Y* yen if they knew that they had a *p%* chance of winning 10 000 yen—and other questions like the one shown in **Figure 3 (a)**—to ascertain the prices they would pay for tickets. Eight questions are asked for each of six different probabilities: 5%, 10%, 30%, 50%, 80%, and 95%. The prices they would pay and the corresponding probabilities are then fitted to an inverse sigmoid function to calculate the examinee's rational-decision making ability. This calculation is done using functions in the statistical package R.

- Decision-making task: risk avoidance

  In this test, examinees are asked whether they would accept (for example) a 50% chance to either lose 10 000 yen or gain λ × 10 000 yen, where λ is a risk aversion index between 0.3 and 10. An example question is shown in **Figure 3 (b)**. The examinee's risk-avoidance tendencies are then calculated from the results.

- Decision-making task: delayed reward discounting

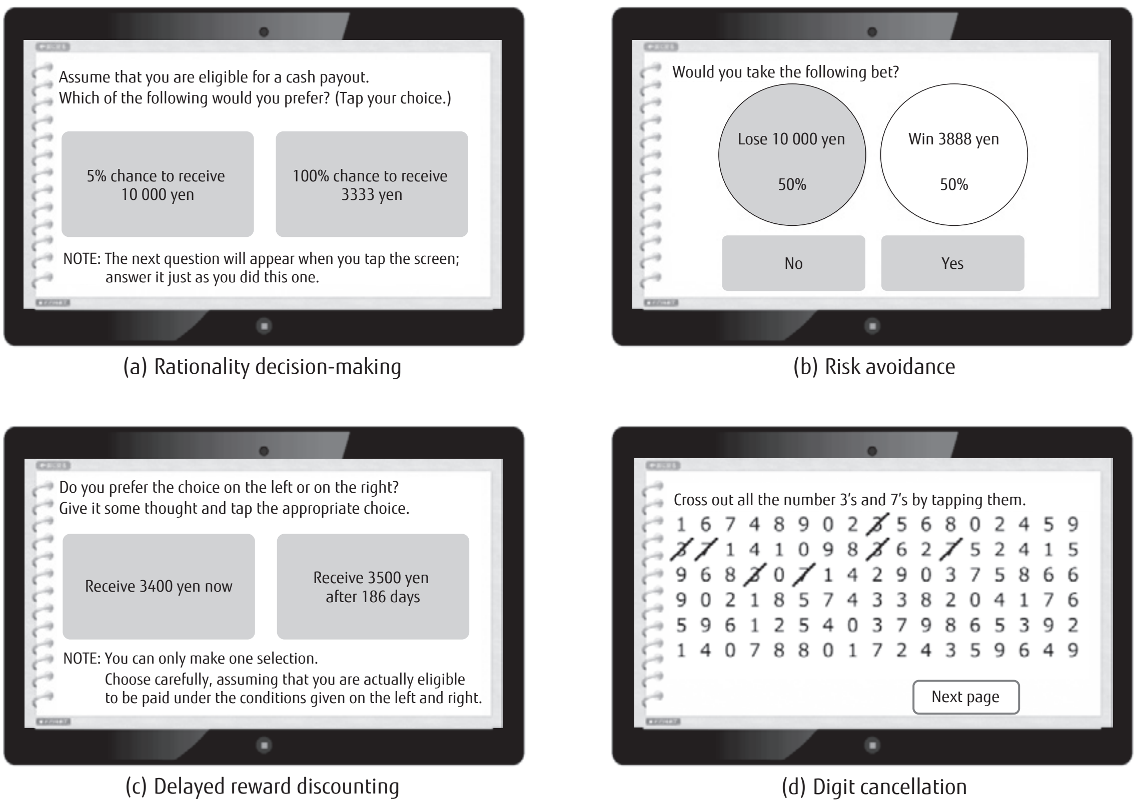
  In this test, examinees are shown 29 questions like the one in **Figure 3 (c)** asking them to choose between a smaller reward now (instant gratification) and a larger reward in the future (delayed gratification). The examinees' delay discounting rate is calculated from their responses. Each of the 29 questions uses an instant discount rate between 0.00016 and 0.25 and three different reward sizes. The geometric mean is then calculated using the delay discounting rate for the first immediate reward and the last delayed reward chosen by the examinee, and the examinee's delay discounting rate is determined by calculating the delay discounting rate for the three reward sizes that were chosen last.

- Cognitive function: digit cancellation

  A digit cancellation test is used to measure (screen for) attentiveness. As shown in **Figure 3 (d)**, examinees are shown a large array of digits and are asked to find (cross out) as many instances of a few specific numbers as possible. The results include the amount of work done, the number of target digits that were correctly crossed out, the number of digits that were incorrectly crossed out, the number of digits that were missed, and the percentage of digits that were missed. Since an important part of this test is determining how many digits can be crossed off in a set amount of time, examinees are shown a video tutorial explaining how the test works before it begins.

- Cognitive function: counteracting interference

  A Stroop test is used to measure an examinee's ability to counteract interference during recognition tasks. The examinee is asked to complete the following four tasks in a fixed amount of time.



(a) Rationality decision-making

(b) Risk avoidance

(c) Delayed reward discounting

(d) Digit cancellation

Figure 3
Example screens for cognitive psychological examination application.

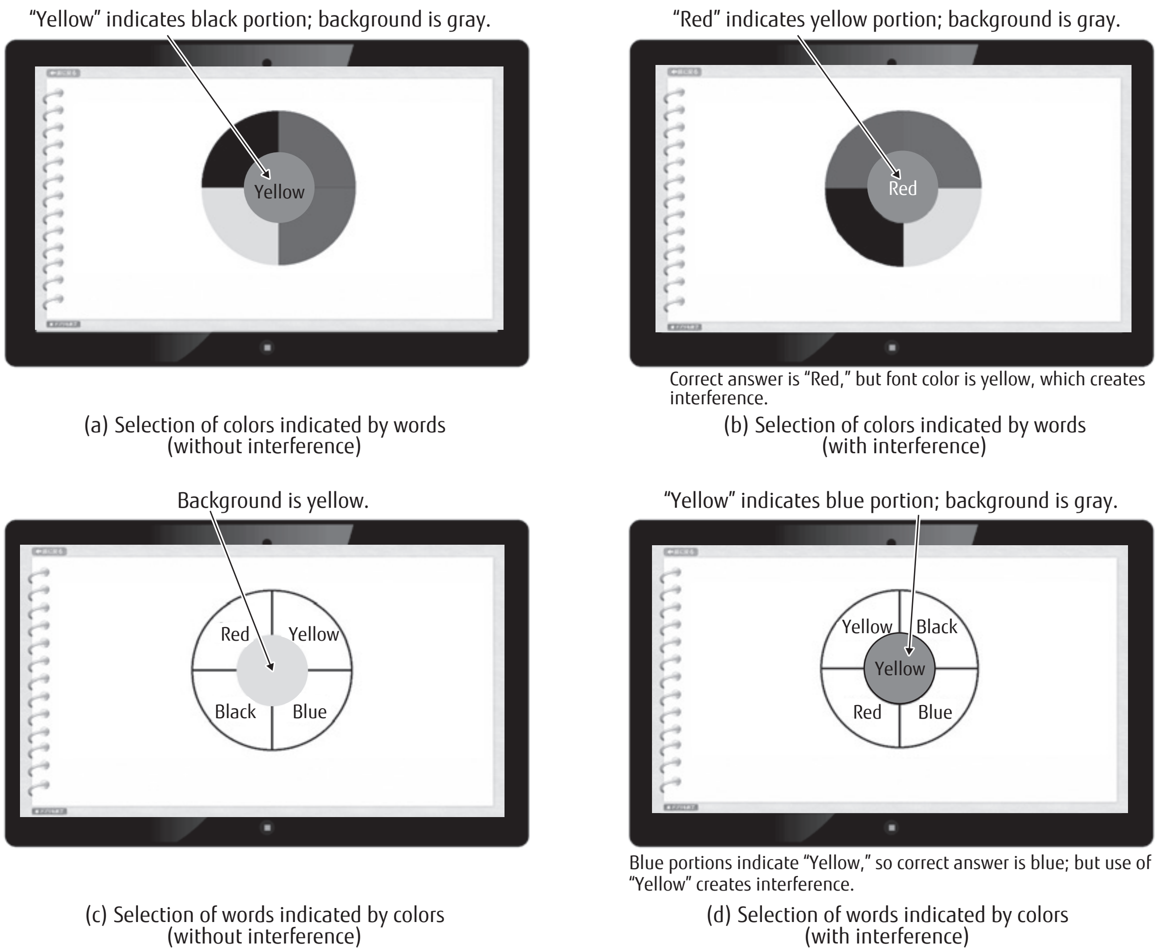


Figure 4
Stroop test.

- without interference, choose the color indicated by a word [**Figure 4 (a)**]
- with interference, choose the color indicated by a word [**Figure 4 (b)**]
- without interference, choose the word indicated by a color [**Figure 4 (c)**]
- with interference, choose the word indicated by a color [**Figure 4 (d)**]

For example, the task of choosing the word indicated by a color without interference involves choosing from four words that surround a colored circle in the center of the screen [Figure 4 (c)].

The results for all four tasks are used to calculate the number of selections made, the number of correct and incorrect responses, the Stroop effect (an indicator of the degree to which interference affects reaction times), and the reverse Stroop effect (an indicator of the degree to which incongruent colors interfere with reading). Because the number of selections made in the allotted time is an important part of this test, examinees are shown a video explaining how the test works—just as they are for the digit cancellation test.

4. Conclusion

In this paper, we introduced the system we developed to support the longitudinal health study being conducted by the Tohoku Medical Megabank Organization. This system runs on Windows 8 tablets and currently supports seven health testing applications that are on a Windows Store application form.

The combination of Windows 8 tablets and Windows Store apps enabled us to develop software in a variety of programming languages and provide an immersive experience to users. We made use of

HTML, CSS, and other Web development technologies supported by Windows Store apps and our accumulated expertise in the areas of usability and accessibility to create a user interface that can accommodate a wide variety of anticipated user scenarios.

The Windows Store apps are subject to restrictions on how they share data and on the directories to which they can write. Taking this into consideration, we think that we can build an internal system with an exemplary user interface not by using Windows Store apps exclusively but by using them in combination with conventional Windows apps. The implementation of the sideloading process is still an issue when Windows Store apps are used within a company. We believe that we can combine PowerShell with Microsoft Windows Script Host (WSH) scripts, VBScript, HTML applications, and other technologies to build an update system with a graphical user interface (GUI).

Finally, we hope that by building this system we have made a contribution, however small, to the recovery efforts for the 2011 Tohoku earthquake and tsunami.

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