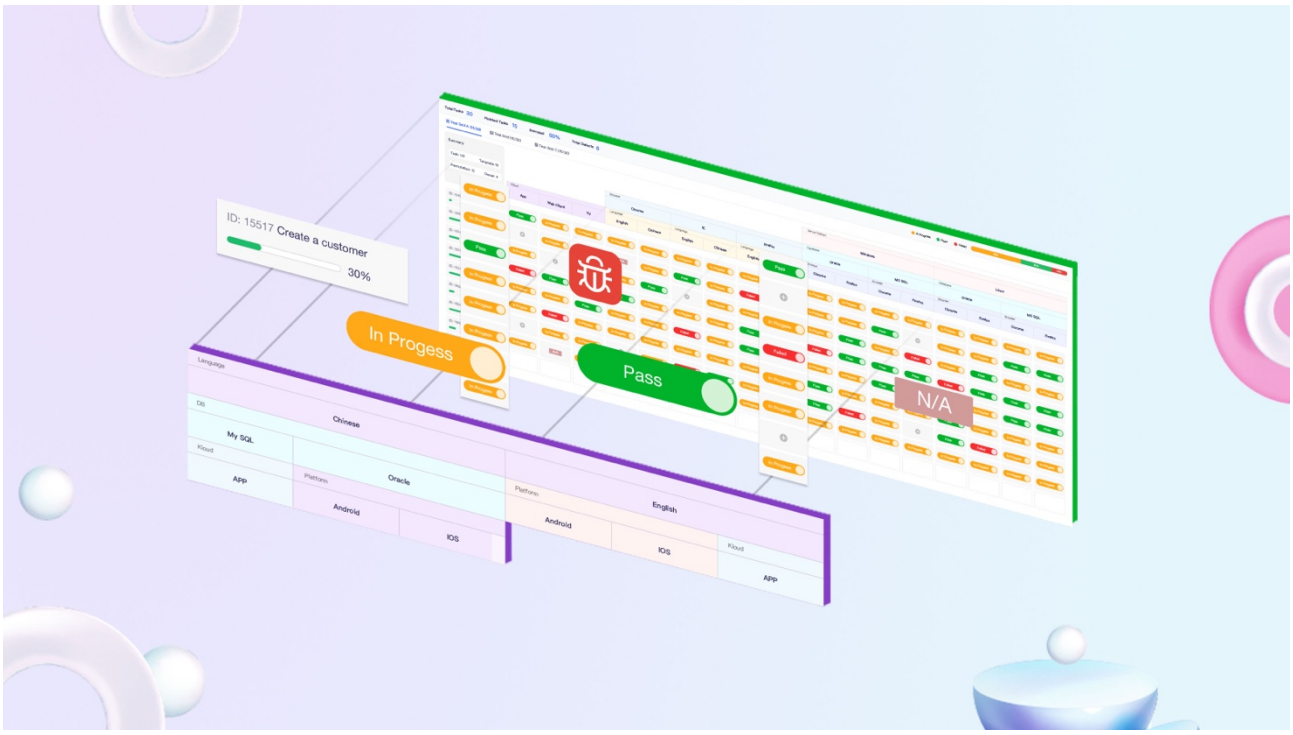


Improve Test Coverage To Account For Run-Time Environmental Variations

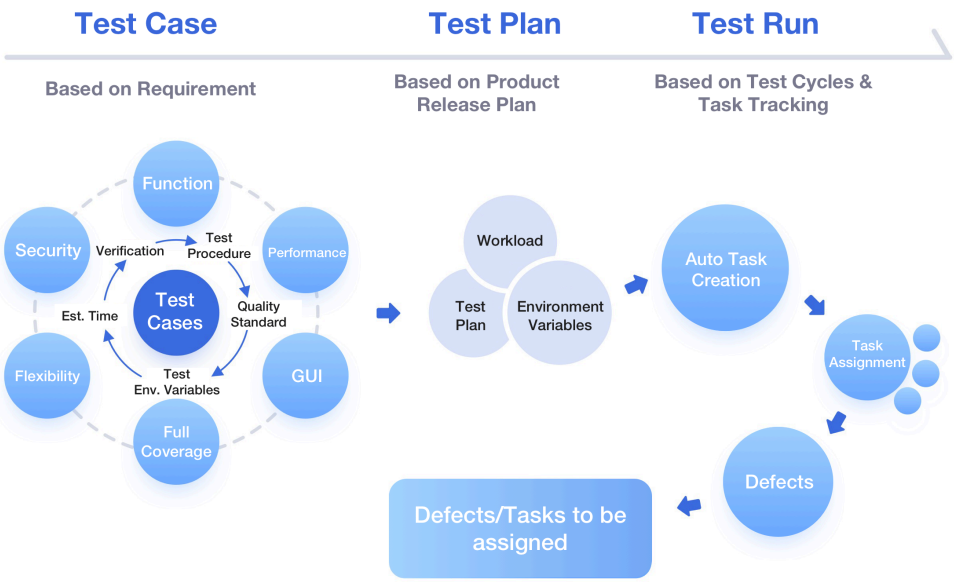
Author: Dr. Tieren Zhou, CEO – TechExcel, Inc.

Traditional testing involves defining test cases and assigning human testers or deploy automated testing tools to ensure that each feature works properly. However, to fully ensure that these features are working, we must consider the environments and changes to those environments where your products are actually deployed.

Run-time environmental variations can drastically affect the way your products behave. It's another layer added to any functional or performance testing and can make testing complex. In this white paper, we will discuss techniques for optimizing the scope of your tests to include these run-time environmental changes.

Planning and Executing Test Coverage

Any testing should include test cases that define the procedures and expected results carefully, a thorough test plan that includes these test cases, and test runs that are executed according to the test plan.



Terms to Consider

- Test Cases and Test Library – The test library contains all test cases associated with a product. Its properties include testing instructions, expected results and various environments a test case can be run under.

- Test Procedure and Test Results – Define the testing procedure such that it can be executed manually or automatically. The expected results should be defined in a way that after running the test procedure, the behavior is as designed.

- Test Case Verification Points – When defining the test procedure, consider whether or not you need to verify specific points during testing to conclude if the test is successful or not.

- Test Case Environmental Variables – Define environment variables under which the test case can be executed. For example, the test case may be run against Windows or Linux, operating system being the environment variable.

- Release Plan – Define the test coverage of the release to achieve the desired quality level. Create as many test cycles underneath the release to fulfill the coverage. For example, the test coverage should include all languages, all major operating systems, etc, that your product needs to run on.

- Test Cycle – Define as many test cycles as needed to adhere to the coverage defined by the parent release. A test cycle defines a target set of test cases with each test case potentially spawning multiple tasks based on chosen environments. It's also where test execution occurs. For example, a specific test cycle may focus on the mobile platform while another focuses on

web with the parent release covering all platforms.

- Test Tasks – Test tasks originate from test cases. It's an instance of a test case defined for a specific environment the test case needs to run.

- Environmental Variable Variations – Environmental variables and a combination of their variations presents a unique challenge to QA. Due to the sheer number of variations, it's difficult to achieve full coverage. There are computerized test coverage models to quantify test coverage by selecting combinations of these EV variations. We will discuss both the combination model vs. the street model.

Defining Test Plans for Functional Coverage

We can categorize test coverage into two coverage areas: functional testing coverage and coverage with run-time environmental variable variations. For function testing coverage, there are mainly four sources to retrieve test cases from.

- Via Test Case Library – Test case library is organized by function areas and often can accommodate thousands of test cases.
- Via requirement (or product functions) – All products are created based on a defined set of requirements. We can tie test cases to these requirements and when planning releases and test cycles, we can select from these requirements to generate a set of test cases that need to be tested.
- Via previous testing cycles and testing activities – By analyzing results of previous and current test cycles, failed test cases may be retested again. Combined with recent development activity, we can identify defects that have been corrected to pull test cases that need to be retested as well.
- Via development efforts – Since development tasks and test cases are linked with parent requirements, one of the sources for selecting test cases can be from developed tasks whether they are newly fixed defects or new features.

Defining Test Plans with Run-Time Environmental Variations

To cover all run-time variations, we must use a method to represent run-time variation via definable variables and their variations. To achieve this purpose, Environmental Variables are used. For each variable we define a list of possible variations via its applicable values (or choices).

For example, a software can run under Windows or Linux, and can also run using SQL Server, Oracle or MySQL which gives us a total of six combinations.

To further define applicable EV's via rules, we introduce a concept of applicable rules for each test case. Choices are "All Applicable", "Selected Applicable", and "Not Related".

In the following sections, we will describe two models which both use environment variables and its variations for coverage.

The Combination Model for Test Grids

The combination model is the more straightforward of the two. It can be defined using the following steps:

- Select a set of run-time environment variables
- For each variable select what the applicable choices are
- Set the Display Order of variables
- Set the Display Order of applicable choices
- Form the combinations for the selected variables and their applicable choices
- Form the testing grid
- Use applicable rules for each test case, form the testing grid

The picture below shows the user interface to define a test release plan or test cycle via a Combination Test Grid.

Applicable EV	Applicable EV Choices
Server System	Windows Server
	Linux Server
Database	Oracle
	MS SQL
Device	Web
	iPhone
	Android

Windows Server						Linux Server					
Oracle			MS SQL			Oracle			Oracle		
Web	iPhone	Android	Web	iPhone	Android	Web	iPhone	Android	Web	iPhone	Android

It is a normalized testing grid where each column represents a fixed set of variables with a unique combination of choices of each variable. It is normalized because the combination takes the same set of variables for each column.

Summary:

Task: 30 Template: 5

Permutation: 6 Owner: 1

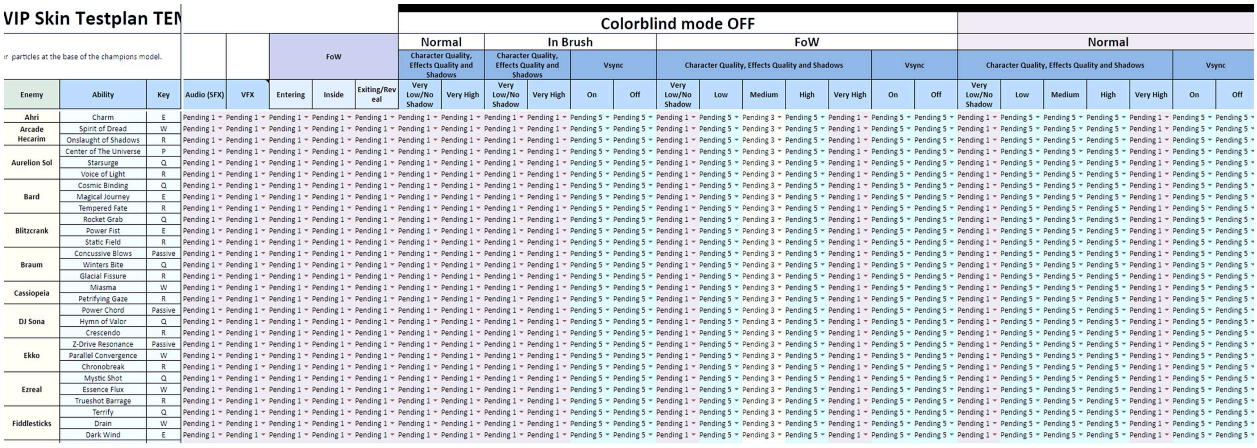
Server Systems

	Windows									Linux								
Databasee	MySQL			Oracle			MS SQL			MySQL			Oracle			MS SQL		
Device	iPhone	Android	Web	iPhone	Android	Web	iPhone	Android	Web	iPhone	Android	Web	iPhone	Android	Web	iPhone	Android	Web
16547 Email Confirmation	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
16601 Create Project, add feature for sele...	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
16607 Forget password testing via phone ...	☑	☑	☑	☑	☑	N/A	☑	☑	☑	☑	☑	☐	☑	☑	☑	☑	☑	☑
16609 Change folder icon according to fo...	N/A	☑	☑	☑	☐	☑	☑	N/A	☑	☑	☐	☑	☑	N/A	☑	☐	☑	☑
16617 Switch Project Space in Toolbar	N/A	☑	☑	☑	☐	☑	☑	☑	☐	☑	☑	☑	☑	N/A	☑	☐	☑	☑
16618 Improve Edit Spec item's Title field	☑	☑	☑	N/A	☑	☑	☐	☑	☑	☑	N/A	☑	☑	☑	☑	☑	☑	☑
16619 Development Module, support sho...	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☐	☑	☑	☑	☑	☑
16628 Improve Attachment section	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑

The Street Model for Test Grids

The street model test grid works in a more flexible way and can provides a highly customizable test matrix. It offers an Intuitive, Excel-like UI for designing EV and their variations.

The grid contains both x and y axes and a combination of environments and its choices. The picture below is an example of a coverage for a video game built as a test grid using Excel:



VIP Skin Testplan TEN

Colorblind mode OFF

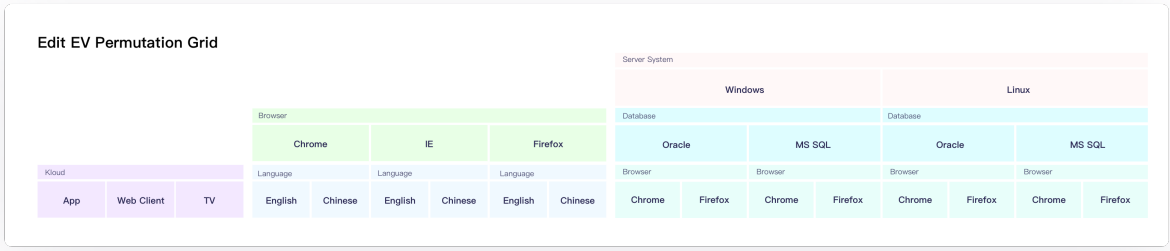
								Normal		In Brush				FoW							Normal						
r particles at the base of the champions model.					FoW			Character Quality, Effects Quality and Shadows		Character Quality, Effects Quality and Shadows		Vsync		Character Quality, Effects Quality and Shadows					Vsync		Character Quality, Effects Quality and Shadows					Vsync	
Enemy	Ability	Key	Audio (SFX)	VFX	Entering	Inside	Exiting/Reveal	Very Low/No Shadow	Very High	Very Low/No Shadow	Very High	On	Off	Very Low/No Shadow	Low	Medium	High	Very High	On	Off	Very Low/No Shadow	Low	Medium	High	Very High	On	Off
Ahri	Charm	E	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 3	Pending 5	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5
Arcade Hecarim	Spirit of Dread	W	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 3	Pending 5	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5
	Onslaught of Shadows	R	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 3	Pending 5	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5
Aurelion Sol	Center of The Universe	P	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 3	Pending 5	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5
	Starsurge	Q	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 3	Pending 5	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5
Bard	Voice of Light	R	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 3	Pending 5	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5
	Cosmic Binding	Q	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 3	Pending 5	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5
	Magical Journey	E	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 3	Pending 5	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5
	Tempered Fate	R	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 3	Pending 5	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5
Blitzcrank	Rocket Grab	Q	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 3	Pending 5	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5
	Power Fist	E	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 3	Pending 5	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5
	Static Field	R	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 3	Pending 5	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5
Braum	Concussive Blows	Passive	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 3	Pending 5	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5
	Winters Bite	Q	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 3	Pending 5	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5
	Glacial Fissure	R	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 3	Pending 5	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5
Cassiopeia	Miasma	W	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 3	Pending 5	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5
	Petrifying Gaze	R	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 3	Pending 5	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5
DJ Sona	Power Chord	Passive	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 3	Pending 5	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5
	Hymn of Valor	Q	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 3	Pending 5	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5
	Crescendo	R	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 3	Pending 5	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5
Ekko	2-Drive Resonance	Passive	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 3	Pending 5	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5
	Parallel Convergence	W	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 3	Pending 5	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5
	Chronobreak	R	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 3	Pending 5	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5
Ezreal	Mystic Shot	Q	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 3	Pending 5	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5
	Essence Flux	W	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 3	Pending 5	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5
	Trueshot Barrage	R	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 3	Pending 5	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5
Fiddlesticks	Terrify	Q	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 3	Pending 5	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5
	Drain	W	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 3	Pending 5	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5
	Dark Wind	E	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 3	Pending 5	Pending 1	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5	Pending 5	Pending 1	Pending 5	Pending 5

To understand this model, we use a concept of a street with retail stores to illustrate.

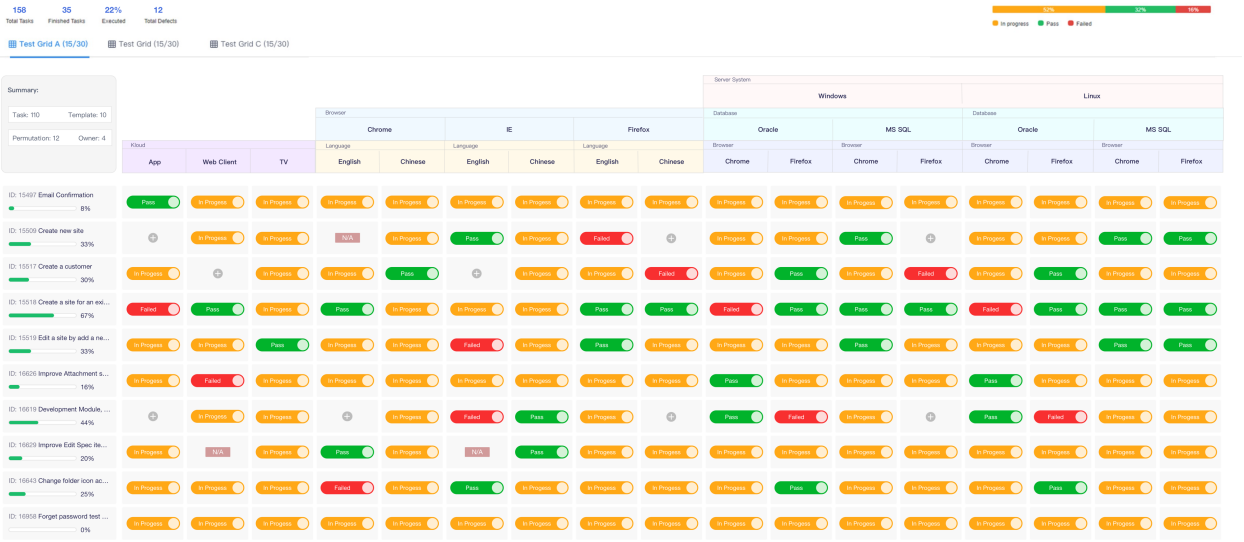
- A retail street consists of multi-level buildings
- Each floor consists of stores selling different types of products from different manufacturers (brands)
- Products correspond to EV variables, and brands represent EV Choices
- A store starts from the top floor with one product type (EV) with one or more brands (choices)
- From each store of any floor, you add more stores above. This is comparable to selecting a new EV variable and its choices.
- When the building is completed, all stores are always at street level. In the street model, as you add EV's on top of each other, they are normalized because the lowest level EV is pushed down

to the ground level, eventually looking like multi-floor buildings.

- The street always consists of a unique combination of stores, or environment variables.



In the illustration below, the test plan or test cycle is displayed as a street model test grid.



Summary

In a competitive market for software development, the quality of the products is the only thing that really matters. Concept and design cannot cover every environment variation especially when products are put into production use. Fortunately, there is an effective way to ensure that everything might work as planned by improving your test coverage using the above methods.

Whether you use a combination model of a test grid or a street model, both can ensure sustainable success of your products. Optimize the way you test today by improving your test plans and execution especially thousands of test cases need to be tested against ever-changing environment combinations.

TechExcel is the leader in unified Application Lifecycle Management. Customized solutions are tailored for various enterprises and industries, with major usage in the video game industry, defense

organizations and hardware manufacturers. Solutions include requirements management, task tracking and test management which can be integrated or used separately as standalone products.

Dr. Tieren Zhou, CEO and Chief Architect of TechExcel, has for 27 years, been a leader in the DevOp's solution industry by delivering a full suite of leading ALM, IT Service and helpdesk tools. Tieren's patented software development solutions and practical process design has been implemented by more than 2,000 companies in 47 countries. Tieren leads TechExcel's product management teams by providing strong leadership, product vision and innovations. Tieren's doctoral work focused on laboratory automation, conceptual modeling, robotics, and artificial intelligence. He received his master in Computer Science and Ph.D. in Artificial Intelligence from Kansas State University.