Open-architecture, Server-Based Platform for Fleet Monitoring and Diagnostics

Enabling a More Proactive, Self-Sufficient Service Model in the No-Data-Out Era

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Industry trends are driving the need to provide proactive monitoring and diagnostic capability without sending files outside the fab for analysis. In addition, there is a need to more quickly develop and deploy new diagnostics while protecting KT Intellectual Property (IP). GSS is placing newly designed Tooling Servers at key fabs for in-fab, self-sufficient support by KT personnel. The servers collect a broad range of parameters and system events. They host KlearPoint Tool Kit, which provides Operational/Interrupt, Parametric and Matching reports with history and comparison to specification and across multiple tools, and proactively provides subscriber alerts. Unlike previous KlearPoint architectures, product groups can write their own applets that interact with the KlearPoint data store. In addition, Tooling Servers can host traditional Engineering diagnostics on a Virtual Machine.

I. Introduction

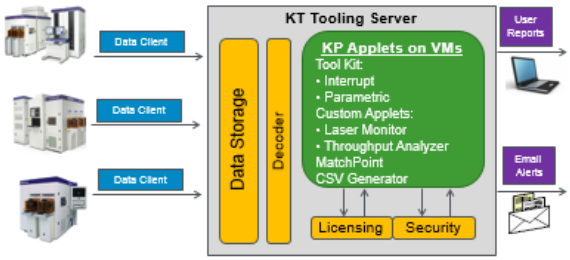
Requirements for more comprehensive system monitoring and rapid, proactive diagnostics are increasing sharply due to multiple trends:

- Customer adoption of comprehensive Fault Detection and Classification (FDC) data collection and "Big Data" approaches to monitoring and enhancing performance of their fabs, increasing the customers' expectations of what KT should also do
- Tightening customer IP requirements limiting data that can be removed from fabs for analysis at KT headquarters
- RIsing cost per hour of system downtime to the customer
- Increasing complexity of servicing measurement and inspection systems
- More system development and spec validation being done at customer sites
- Growth in the size and number of data sources and types needed for diagnosis
- Rising costs of key parts such as lasers which can be unnecessarily replaced
- Expanding use of Legacy KT Systems in "More-than-Moore" applications

The KlearPoint program has developed a new, lower-cost server to support in-fab system monitoring and diagnosis. Unlike earlier KlearPoint architectures, it is now straightforward for any software or systems team to write "applets" which can run on the KlearPoint server.

II. Description of new KlearPoint architecture

The KlearPoint server, placed at customer sites at GSS's cost, is referred to as the "Tooling Server". It is a tool for KT personnel rather than a product for a customer.



The KT Tooling Server includes data storage, decoder for data access, security, licensing, and the diagnostics applications themselves, known as applets. To transfer data to the server, each connected KT System has the data client installed. Data is passed to the client using the provided API in XML format. The client converts this to an encrypted CSV format, which is transferred to the server. In addition, the client can be configured to transfer key files such as tool logs for centralized access.

Applets are used by logging into Virtual Machines (VM's). Users are authenticated using KlearPoint security, which is based on the KTSecurity framework from the CPG software group. Access to content is restricted based on the login credentials used. KT users must use a dynamic passcode linked to the PC and an active service case, which changes every 7 days.

Information transferred to the server is kept in the KlearPoint data storage (for >1yr), and is accessed by applets via the decoder API. The decoder API both validates that the applet is licensed (leveraging CPG's licensing framework), and that the user session is valid.

The system can also send e-mail alerts when a defined event happens. Currently these are configured to send out daily summaries of interrupts and out of limit parametric values. Future expansion will notify subscribers of key events as they are detected.

III. Description of Hardware Monitoring Functions

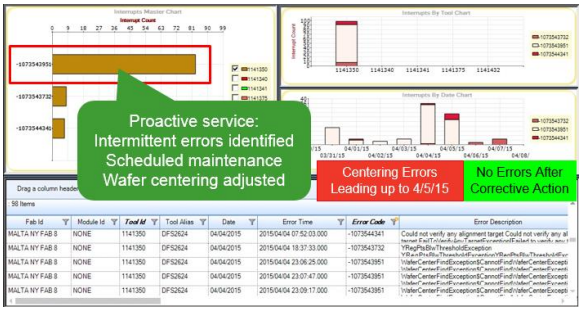
Tool Kit Hardware Reports provide several views of the status of the fleet's parametric data. First, a subsystem summary flags any subsystems with data outside of specifications. The user drills down to the values for that subsystem, where the anomalous points are highlighted. They can view a trend chart showing the historical performance, with the option to overlay data from other tools or other parameters. In the case below, the KT Customer Service Engineer (CSE) found a laser issue on a 9550 system, proactively scheduled service, and confirmed data remained within limits after the corrective action. Early detection prevented a sudden failure of a system in production, reduced the down time, and eliminated risk of damage to the laser.

IV. Description of Operational / Interrupt Monitoring

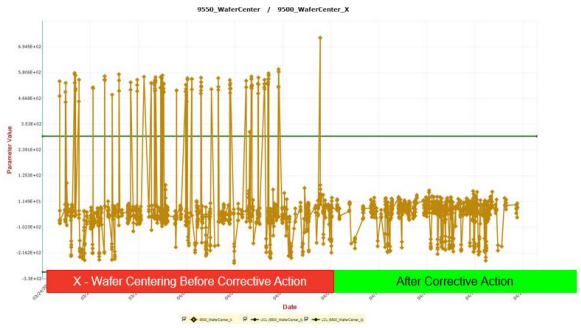
Tool Kit Interrupt Reports quickly identify top issues impacting system Mean Time Between Interrupt (MTBI) by displaying software interrupts in a pareto format. Rather than simply listing all the errors seen on a tool, the KlearPoint software first finds the interrupts, then seeks to identify which error code most likely caused the interrupt. Context information such as recipe name and lot ID, and system activity are also displayed to aid in fault isolation and enable future applications such as Recipe Success.

In the case below, a CSE identified an intermittent centering error. The customer had

not yet noticed a problem with the system.



The CSE then used the hardware monitoring functions of KlearPoint to isolate this to an X-Registration Issue, and scheduled a Corrective Maintenance case. The CSE was able to easily monitor interrupts afterward to confirm the fix.



V. Open Applet Architecture

There is a strong desire to increase the number of Engineers able to develop diagnostic applications, and the speed at which they can be deployed. To address this, a software development kit has been developed for KlearPoint, enabling solutions needed to meet KLA-Tencor requirements on applet licensing, security, and IP protection.

This approach simplifies the development process via software libraries which take care of common requirements like login security, licensing and data access, and creation of applet templates and sample projects with the basic capabilities listed above built in. Most legacy and new software applications written in Matlab and other common languages do not need to be re-coded. Straightforward options are available to interface with the .NET framework.

New and experienced software developers can get started immediately, on a server set up for engineers to create open-source applets in Microsoft Visual Studio. This development environment, with templates, sample projects and an open-source modular design, makes it possible to deliver robust applets from start to release in a few weeks. More importantly, the new infrastructure allows product and systems engineers time to focus on other innovative ways to add value. New applets are then integrated with a new release of KlearPoint software, and distributed to field sites for in-fab use.

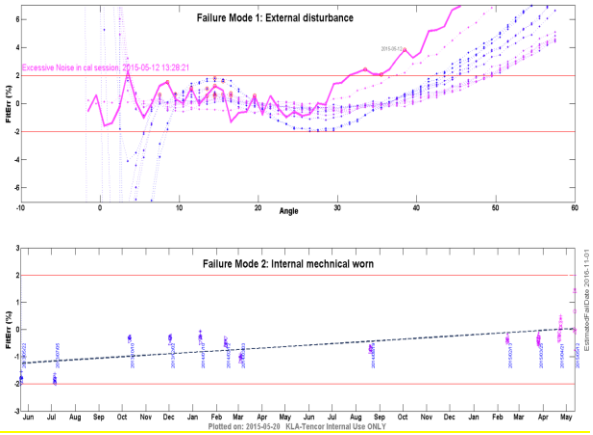
In contrast to diagnostic tools which run on the measurement or inspection system, applets can easily draw long-term data from all tools of similar type running in the fab and compare them. For many products, the applets are also more secure since the customer cannot access these applets.

VI. New opportunities for obsolete measurement and inspection systems

Often, failure modes arise in the field that were not seen at the factory, and the needed diagnostic capability was not designed into the system. Also, legacy KT systems typically send limited data via the KlearPoint client, and software development has ended.

The Tooling Server provides a platform to address these types of issues. The client can be configured to auto-transfer data or image files "as-is" to the Server, providing a new source for data. In addition, the applet framework can be used to develop diagnostics for these legacy systems.

Recently, CSEs were unable to distinguish between failure modes using existing diagnostics, leading to replacement of a $25k optical attenuator module which could have been repaired in the field. An applet has since been created which can proactively identify these issues before hard failure. The applet speeds up analysis from >2 labor hours involving a headquarters expert, to <2 minutes by a local CSE. As seen in the next figure, the different failure modes have very different signatures in this applet.



VII. Virtual Machines for in-fab Engineering work

Some Design Engineering teams have felt the need to place servers in fabs in order to have a practical place to run advanced diagnostics and problem-solve using programs such as Excel, JMP, and Matlab. The Tooling Server is a secure environment for those activities. The KlearPoint program can provide Engineering teams with a Virtual Machine for these purposes.

VIII. Conclusion and Future Work

A new Tooling Server is being placed in key fabs for in-fab, self-sufficient support by KT personnel. The sever includes KlearPoint software with data collection and analysis capabilities for interrupts, hardware parameters and matching. The server allows for new capabilities to be added through applets developed by Engineers throughout KT. It can be leveraged during all phases of the development life cycle, from Engineering prototype through volume production to legacy support.

Future work will include:

- Clients supporting more KT systems
- Recipe Success metrics, for identifying recipes creating errors
- Additional diagnostic applets
- Event-driven e-mail alerts to subscribers
- Predictive Maintenance
- Data-driven Periodic Maintenance (PM) optimization
- Correlation between system parameters and measurement results
- Application of "Big Data" techniques