APC/FDC Implementation Strategy to High Volume Manufacturing

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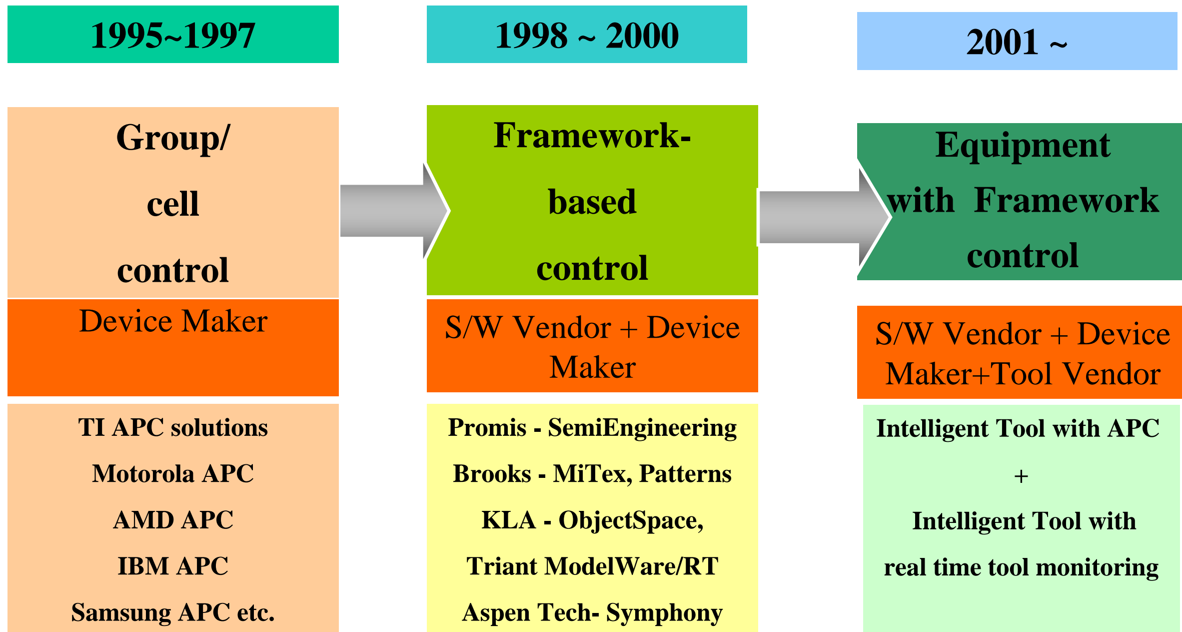
Why do we concern APC/FDC in High Volume Manufacturing?

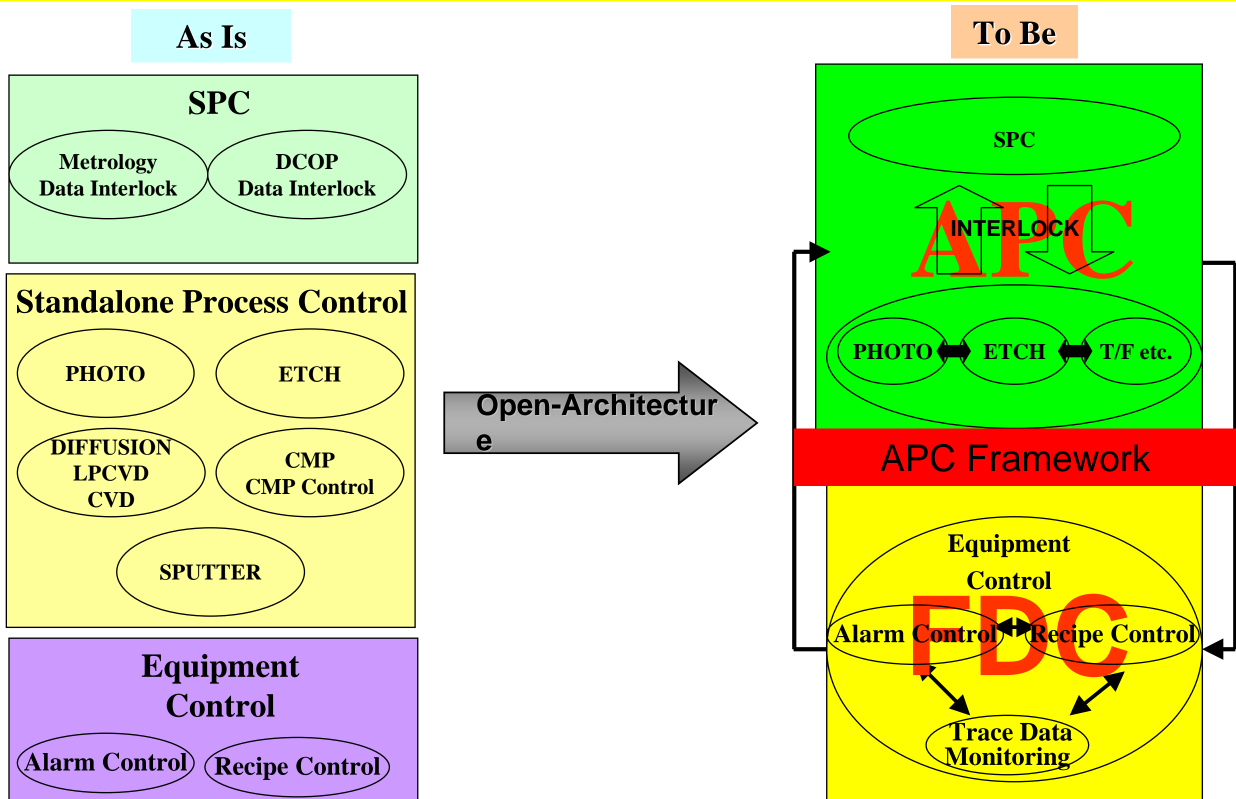
- Tool cost and maintenance cost in 200 / 300mm manufacturing becomes increased and OEE more important.
- Process becomes more complicated and difficult to be controlled by operator and/or engineer in real-time basis.
- Fast new device and equipment setup will contribute to ramp-up.
- Wafer-to-wafer level process and equipment monitoring becomes more important.
- Human error results in wafer loss and increase of costs.
- Full Automation is a trend for future fab operation.
- Real-time process and equipment control is only way to speed up the throughput and prevent the fault and failure.

Key Issues in Implementing APC

- Type of lot (normal, engineering, dummy, test lot)
- Process plan (normal flow, rework flow, split / merge flow, reposition flow)
- Equipment type (chamber, furnace) and Data collection
- Materials (reticle, photo resist, etc.)
- PM (scheduled or unscheduled PM)
- MES integration – Open-architecture issue
- Confliction between scheduling and dispatching vs. APC
- Production behavior (control context matching, metrology data, rework, measurement skip etc.)
- Cost and investment

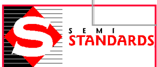
Recent APC/FDC Activity



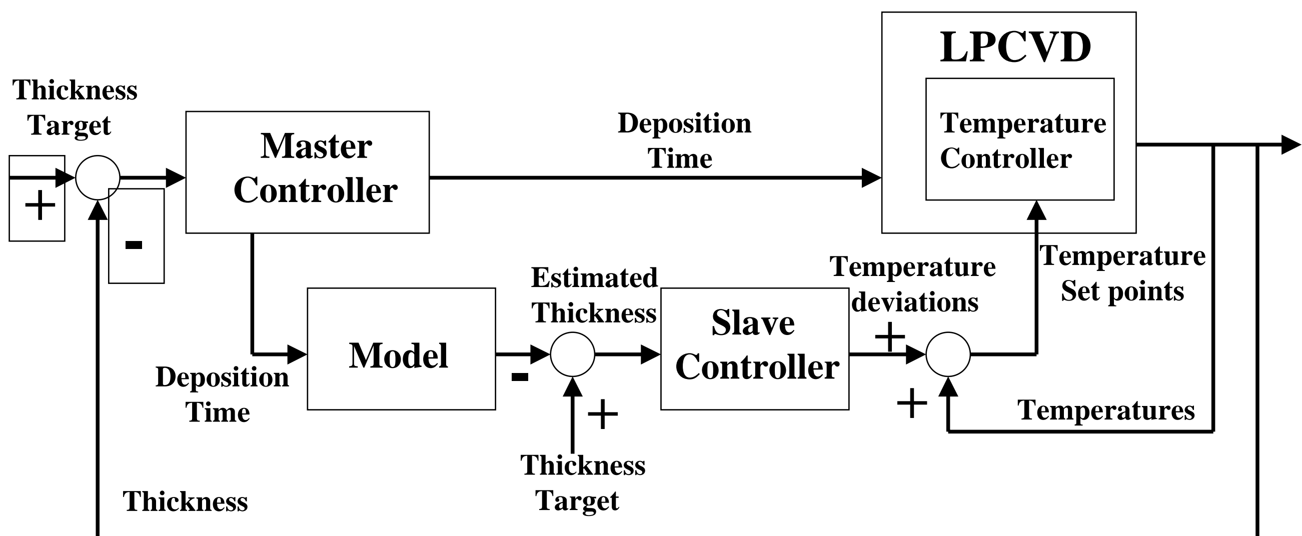


Examples of Process Applying APC Systems

Process	Controlled Variable	Manipulated Variable	Target
CMP	Thickness	Polish Time Down Force	Post-Thickness
Photo	Offset X,Y etc. ADICD Skew	Offset X, Y etc. Dose, time	Offset X, Y etc. ADICD
Etch	ACICD	Etch Time	ACICD
LPCVD	Thickness Temperature	Temperature Deposition Time	Thickness
Sputter	RI	Deposition Time	RI
Diffusion	Thickness Temperature	Deposition Time	Thickness



LPCVD Problem

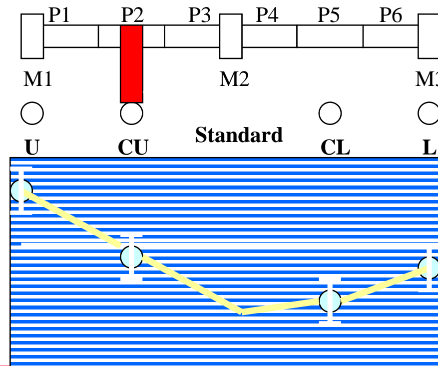


Use Case of Furnace

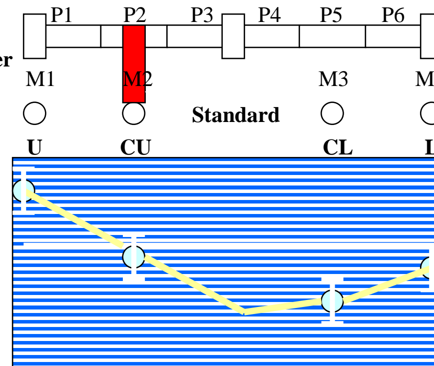
The procedure to calculate the deposition time and temperature set points

- **Selection of standard thickness zone**
- **Calculation of standard zone's deposition time**
- **Calculation of estimated deposition thickness on each furnace position**
- **Calculation of temperature set points using estimated deposition thickness for each furnace zone.**

Case I (Three Monitoring Wafer)



Case II (Four Monitoring Wafer)



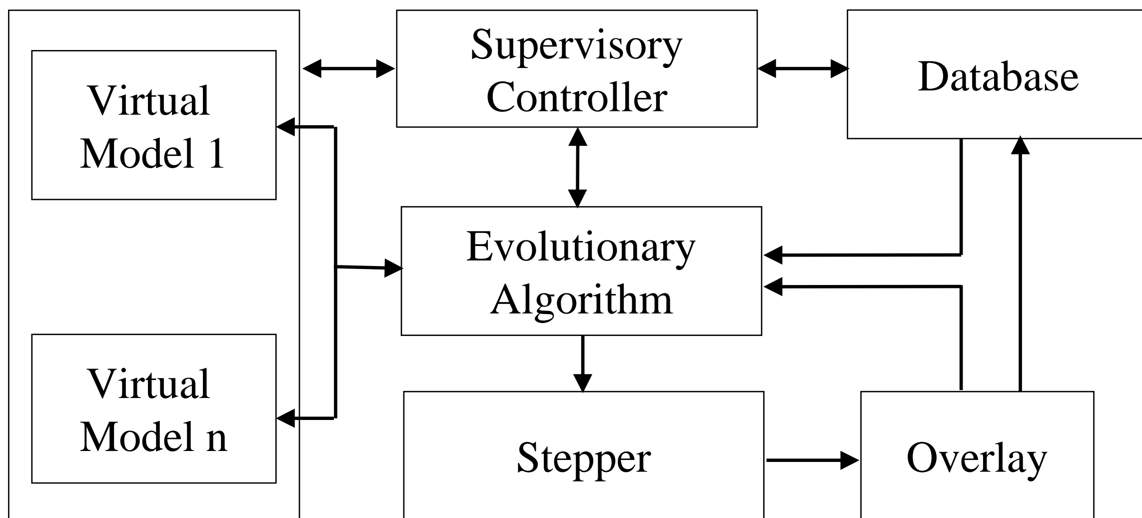
Lot Position

Monitoring Wafer Position

Thermocouple Position

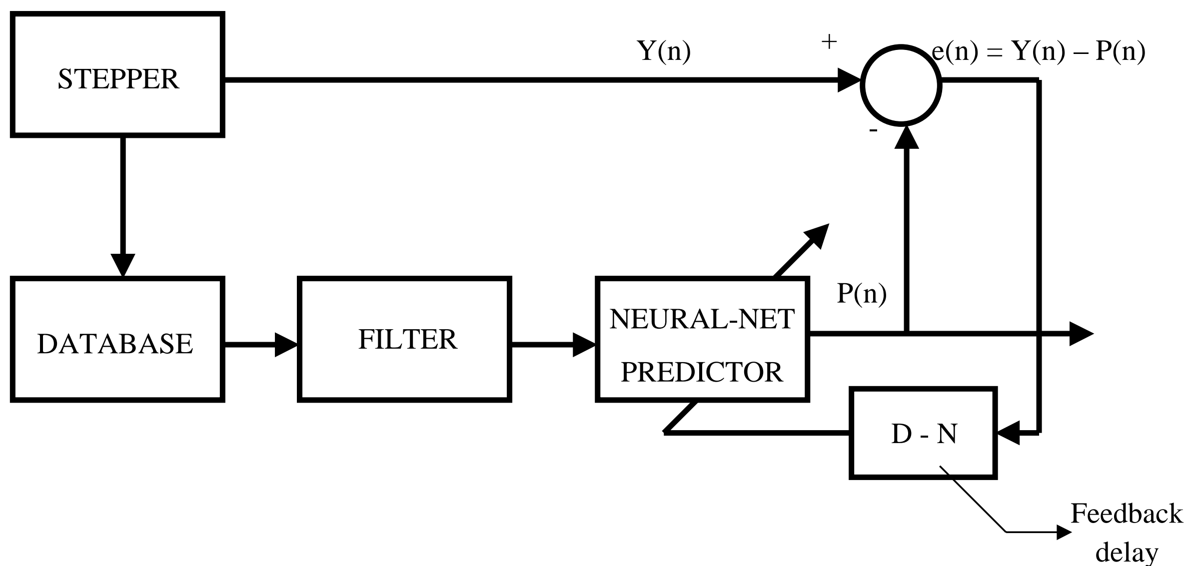
Thickness Profile

Photo Problem

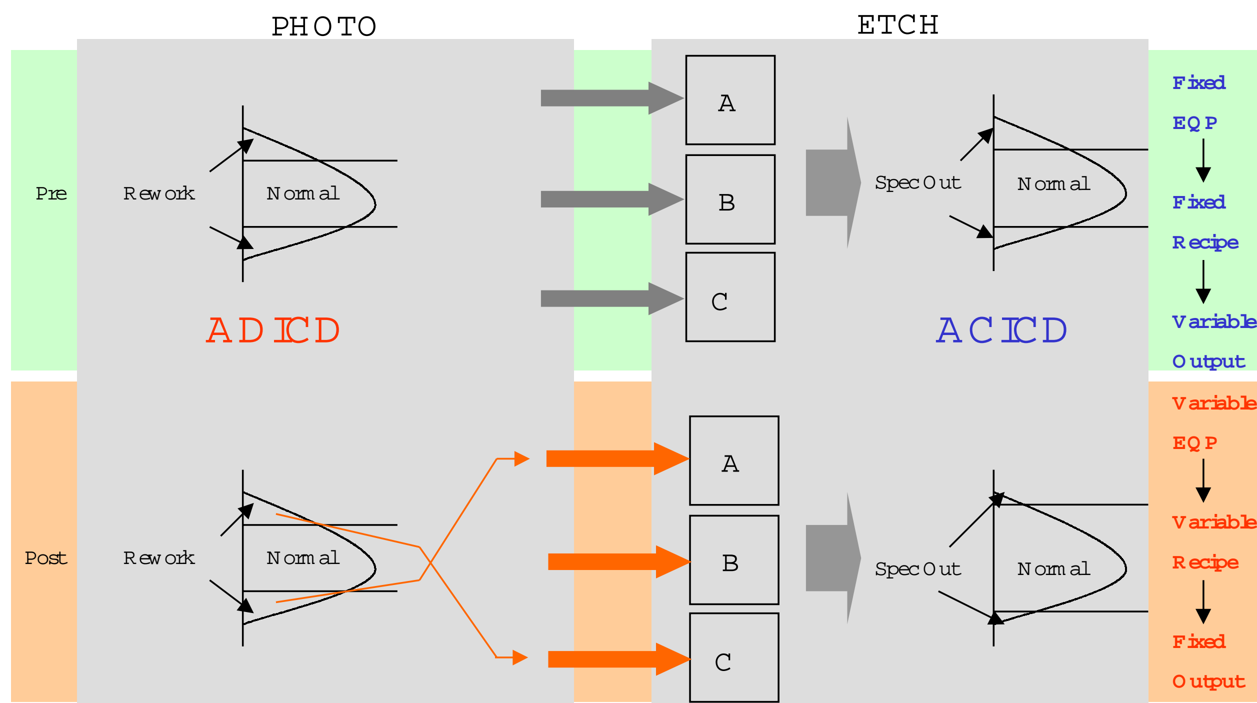


Virtual Plant

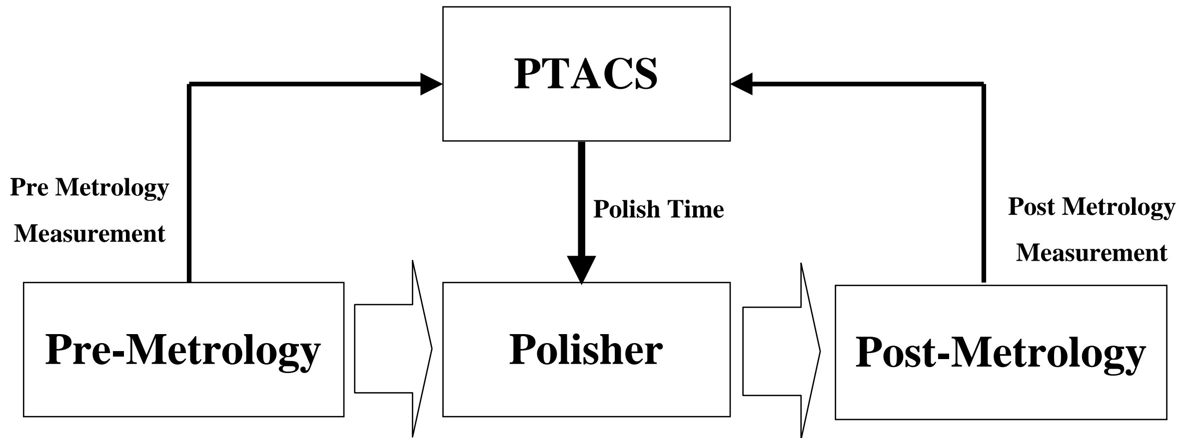
Adaptive LMS Predictor



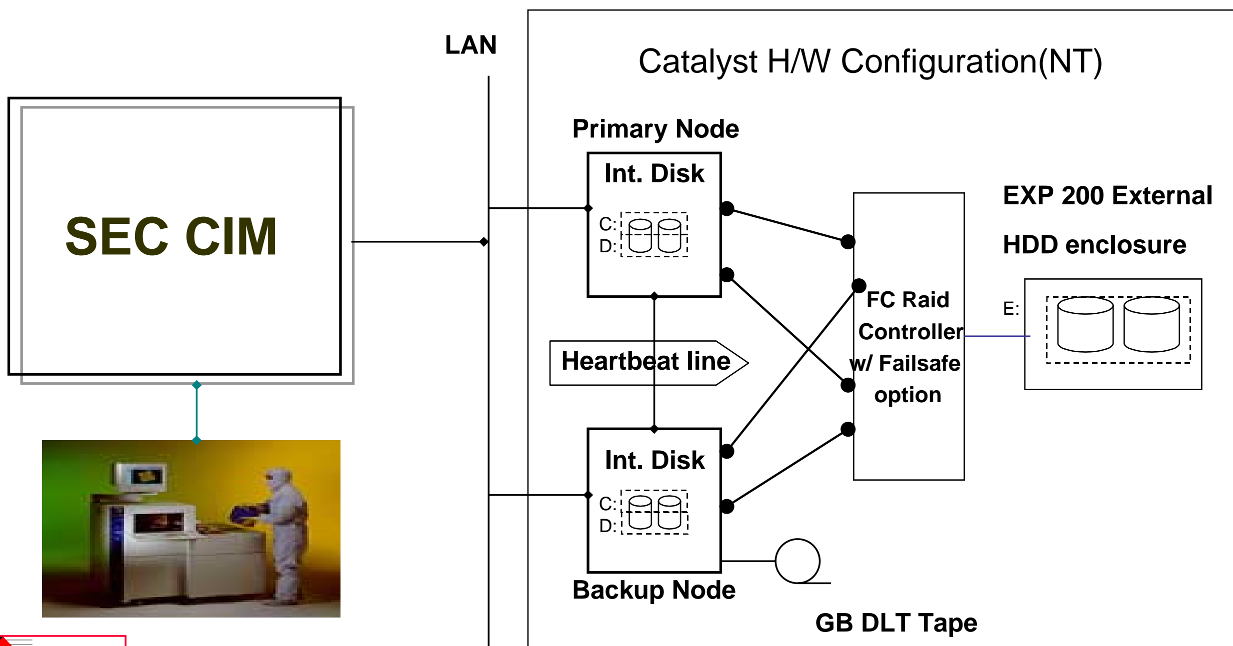
Etch Problem

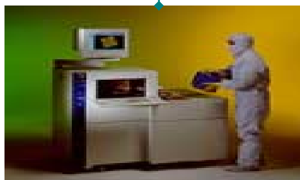


CMP Problem



Factory wide APC H/W Integration Configuration





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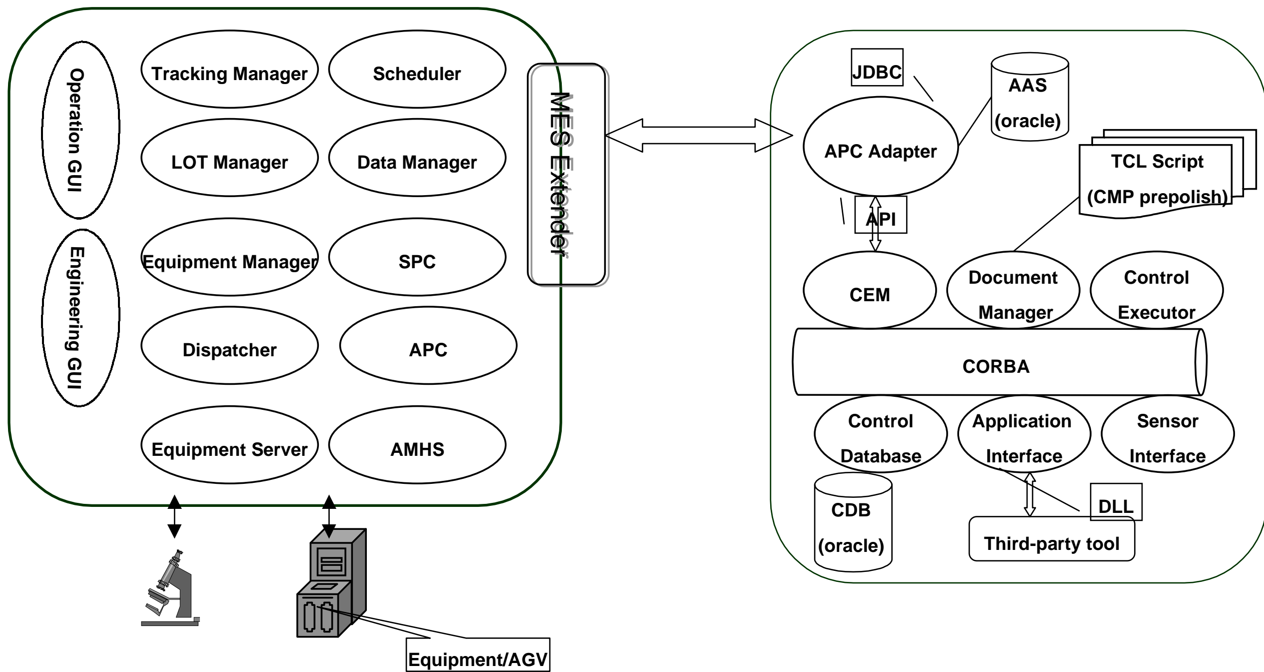
MES & APC S/W Integration Configuration



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APC Suggestions

- ❑ Fab-wide APC solution has to be a proven solution in many process area. (*Solution should be easy to implement and be standardized !!!*).
- ❑ APC solution has to be open-architecture wired with CIM environment.
- ❑ Third party S/W usability (e.g., real-time monitoring, other process analysis tools) has to be extended more.
- ❑ APC must have flexible functionalities under various production environment.
- ❑ APC Systems should guarantee the stability and performance.

Why is FDC Important to a Device Maker?

- Needs for a systematic FDC solution which keeps various manufacturing equipment monitoring capabilities.
  - Real time multivariate chart support (System health must be monitored).
  - Real time Lot/Equipment alarm/holding function interfaced with MES.
  - Real time feedback solution support for engineer's reaction.
- Lot to lot processing with the currently equipment information does not give the exact status of tool. One value such as max, min, and average from the tool does not give the informative prediction to process engineers.
- Equipment monitoring based on wafer level is critical to reduce the wafer loss and preventive monitoring time.
- Process in equipment has to be monitored in real-time basis with the same order of signal gathering.
- For future 300mm wafer production under full automation, FDC will be a critical component.

Benefits of FDC

- Process Technology Innovation
  - ✓ Wafer level monitoring and optimum equipment status modeling
  - ✓ 300 mm production and process technology early setup
- Equipment Monitoring
  - ✓ Prevention of accident, enhancement of throughput, reduction of Test-Wafer, enhanced OEE
  - ✓ Real-time monitoring
  - ✓ PM, effective equipment monitoring after long-term equipment down
- Yield Enhancement
  - ✓ Reduction of rework/scrape and minimize the cost
  - ✓ Treatment of current step of abnormal wafer (EDS Yield enhancement and cost reduction)
- CIM Technology Infra
  - ✓ APC Framework infra
  - ✓ Applications infra

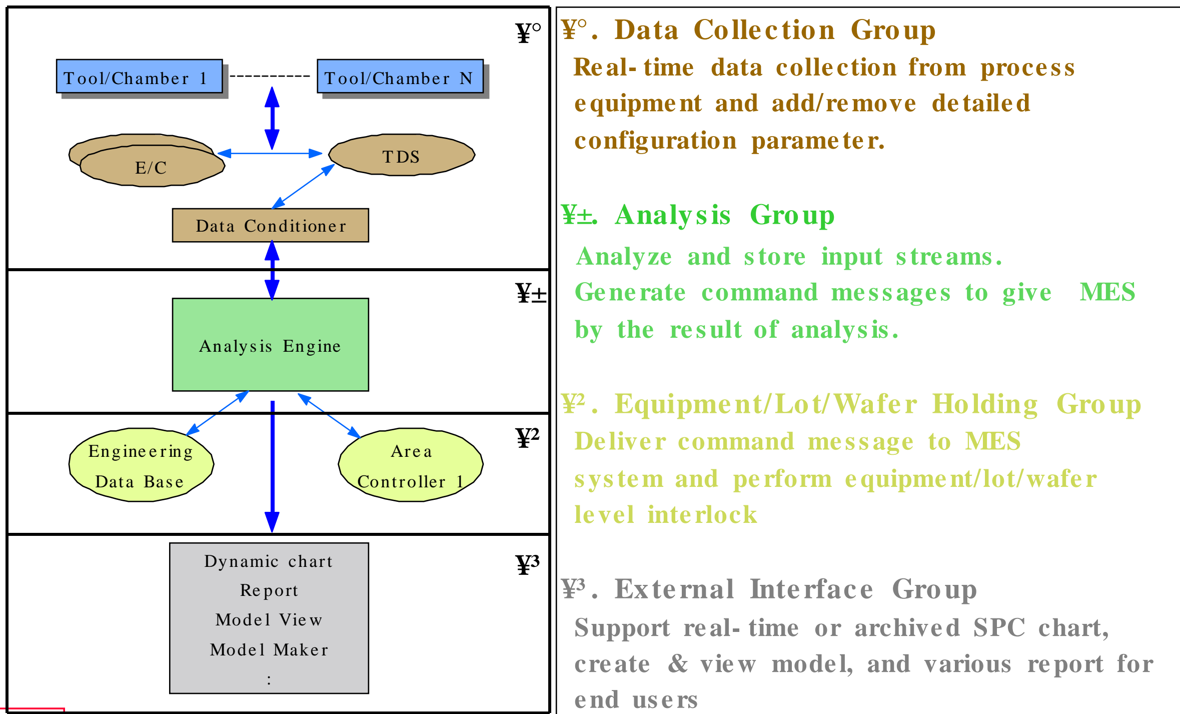
Key Issues Implementing Real-Time FDC

- ❑ Wafer-level trace data has to be obtained for practical equipment monitoring.
- ❑ Connection between tool and FDC system should be simple and network traffic load should be minimal.
- ❑ Additional hardware and software usage for FDC should be excluded in Fab because of maintenance costs and time.
- ❑ FDC system has to have enough hardware capacity for handling huge amount of wafer-level trace data.
- ❑ SECS and HSMS is necessary for easy connectivity between tool and FDC system.
- ❑ For future e-diagnostics, FDC system has to have open-architecture and TCP/IP compatible.

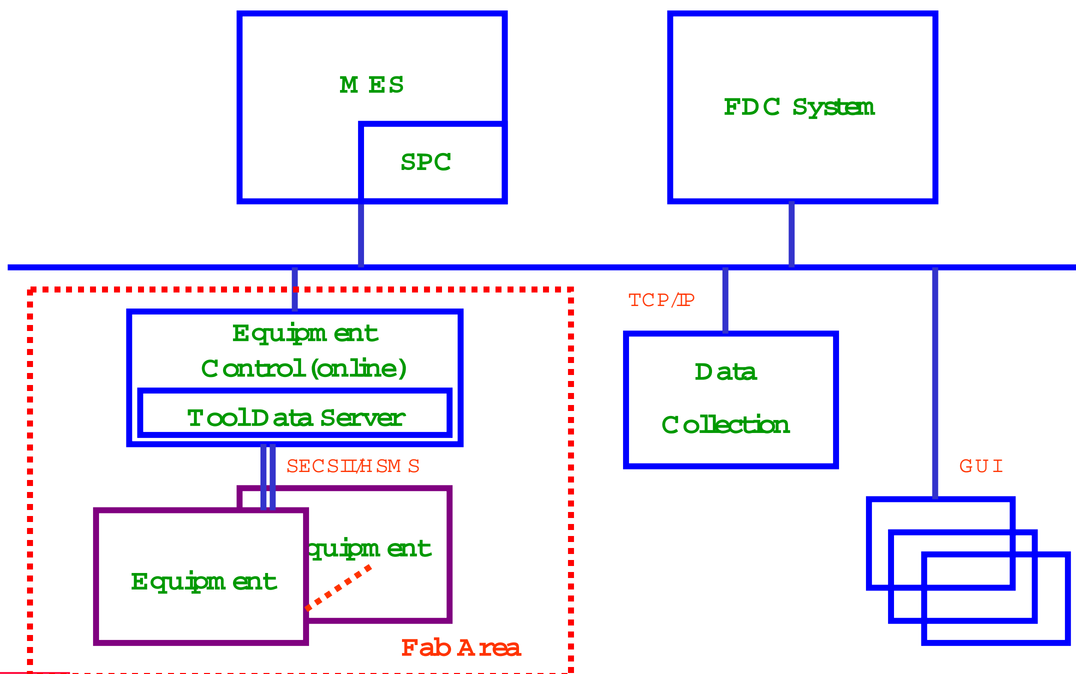
System Requirements

- ❑ **Unix server based architecture (AE)**
- ❑ **Data collection via SECSII using Equipment Controller (EC)**
- ❑ **Tool Data Server (TDS)**
- ❑ **Data Conditioner (DCond)**
- ❑ **Huge shared data storage - *High usability***
- ❑ **Samba based inter process-communication**
- ❑ **Networked operation - Anywhere on the network**
- ❑ **Various report and chart support - Real-time & archived**
- ❑ **MES integration – Lot-Wafer / Equipment**

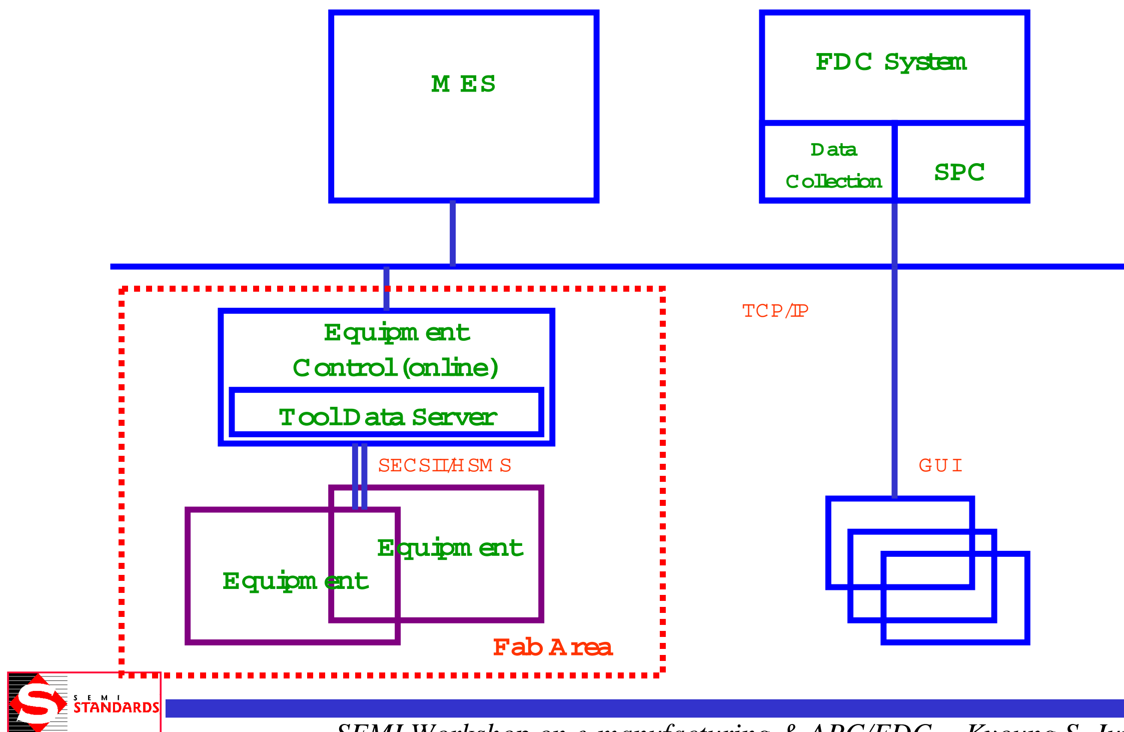
System Configuration



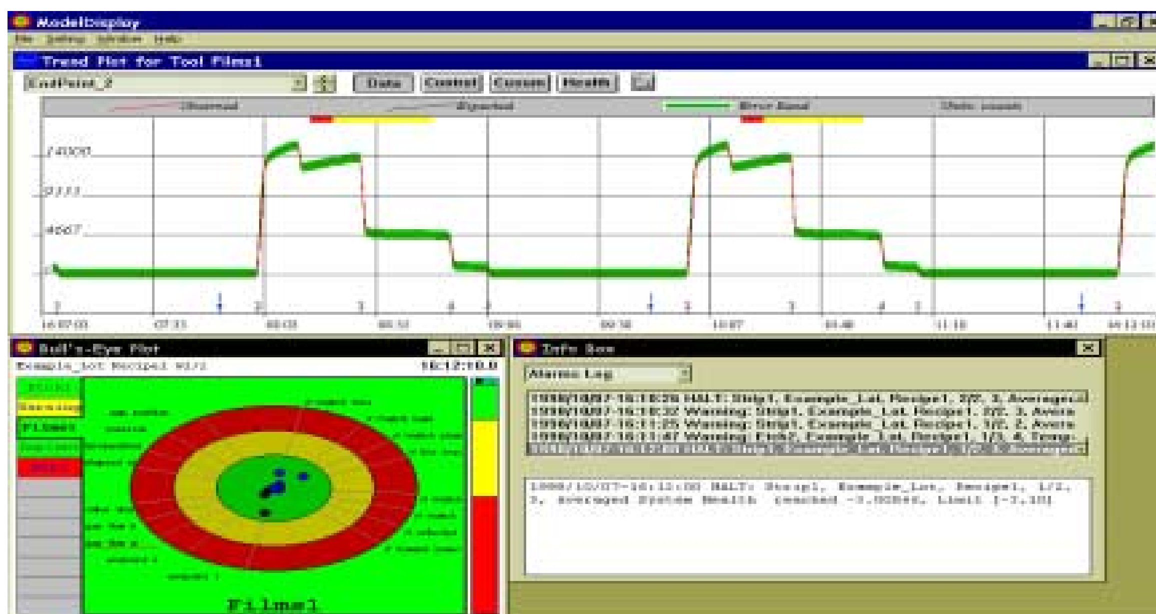
System Architecture (Phase – I)



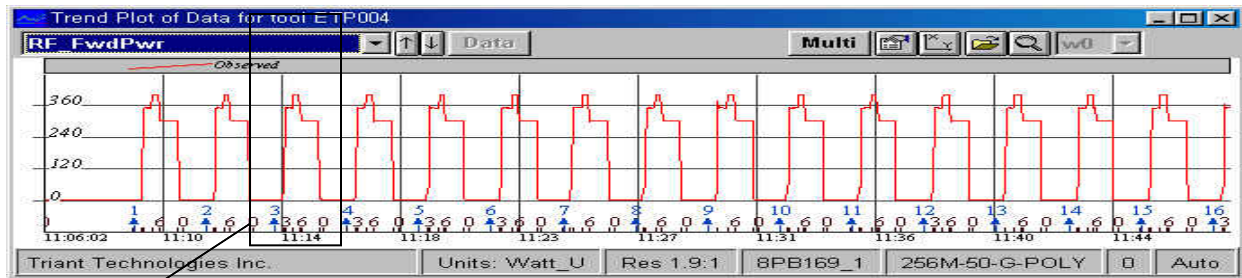
System Architecture (Phase – II)



FDC GUI



Sample GUI (Cont.)




```
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@1 2000/03/02-11:14:26.51    8PB169.1  3   4.045     0.879739  5.75998  0         0
@1 2000/03/02-11:14:28.81    8PB169.1  3   4.04731   1.0246    26.0462  0.152743
@1 2000/03/02-11:14:30.61    8PB169.1  3   4.04546   4.2543    25.9489  0         0
@1 2000/03/02-11:14:32.81    8PB169.1  3   4.04075   4.20724   25.7565  0         0
@1 2000/03/02-11:14:34.91    8PB169.1  3   4.05327   4.27799   25.996   0         0
@1 2000/03/02-11:14:37.31    8PB169.1  3   4.0524    4.26932   25.9359  0.114539
@1 2000/03/02-11:14:39.21    8PB169.1  3   4.04972   4.26365   26.007   0         0
@W 3/0.2
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@W 3/0.3
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```

FDC Suggestions

- Tool has to be stable for sending trace data to equipment server.
- Minimizing network load and storage, but maximizing sensitivity and archiving.
- It is difficult to monitor the tool with variable list type SVIDs
- Equipment server with limited CPUs and memory has a limit for using number of tools for monitoring. Various input and output data handling methods are required (file, socket, middle-ware, DCOM, or other API).
- Fab-wide installation should be simple and capability, stability, and usability will be the first consideration.
- Tool modeling effort should be minimal for reducing engineer's time consuming.
- FDC has to be open-architecture wired with CIM environment.
- Not only tool data analysis but also metrology data related analysis will be welcomed.
- Best thing for device maker is to get equipment with real-time FDC functionality.