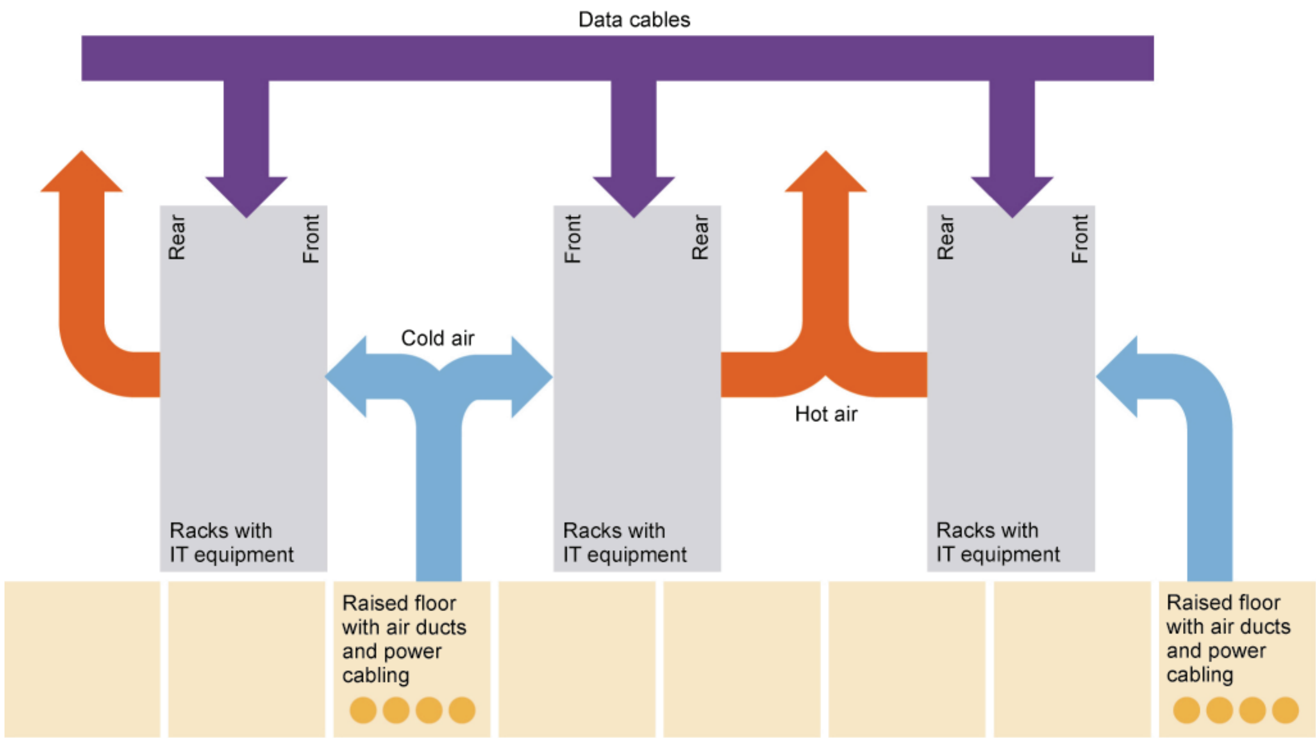
# Green Sustainable Data Centres

## Data Centre Infrastructure Management



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## Data Centre Infrastructure Management

Chapter 6

# Data Centre Infrastructure Management

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## INTRODUCTION

In Chapter 5 we discussed measurement and control of a data centre and concluded that an automated real-time energy monitoring system is required. Data centres are now part of the basic infrastructure of many corporations, companies and government agencies. Running and operating them efficiently and effectively is necessary for the economic viability and delivery of the various functions and services undertaken by these organisations. Failure of any aspect of the data centre can lead to a loss of business capability that is expensive at many levels for an organisation. Data Centre Infrastructure Management (DCIM) are the systems in a data centre that provide this centralised control structure. These are discussed in this Chapter

LEARNING OBJECTIVES
After you have studied this chapter we expect that you are able to
– understand the purpose and architecture of a basic DCIM system
– understand the different types of DCIM systems that are available and their relative advantages and disadvantages
– understand the origin and information streams that flow into a DCIM system
– understand the information content that DCIM presents to different stakeholders in a data centre organisation
– understand how to develop and implement a Green, Sustainable policy in a data centre using DCIM.

*Study hints*
The purpose of this chapter is to give an overview of Data Centre Infrastructure Management (DCIM).
The workload is 12 hours.

## CORE OF STUDY

### 1 Introduction to Data Centre Infrastructure Management

Computing is now a utility. No longer does accessing a state-of-the–art computing infrastructure require a depth of technical knowledge and a huge capital expenditure. All that is required is a thin client agent (e.g. a notebook, low grade lap-top) that has high-speed access to the internet, and then all the heavy computing and storage is performed by the 'Cloud'. Literally, cloud users only need to specify their computing requirements from their cloud providers and pay the fee. They can scale up or down these requirements with minimal effort through the cloud provider's portal. Small businesses can have a complete enterprise solution comprising pay-roll, customer accounts, email, customer service system etc for a few €100's per month.

*Capex*
*Opex*

This ‘pay-as-you-go’ approach to computer services has transformed computing from a *Capex* (capital expenditure = costs of purchase) to an *Opex* (operational expenditure = cost of operation and maintenance) operation. There are no upfront investment or maintenance costs or a necessity to upgrade every 2 or 3 years, this is the responsibility of the cloud provider. However, the cloud is just a abstract conceptualisation of a data centre, so whether we are talking about data centres or the cloud we are really talking about the same physical entity, a building with hundreds or thousands of racks with servers, networked with memory devices and connected to the outside world via the internet. Vast quantities of energy are expended running these computers and cooling them in order to keep them operational. Also, these computing assets have to be managed like any asset in an organisation. They must be recorded in an inventory list and tracked as they are removed or transferred around the data centre or upgraded. In addition, they must be monitored to ensure that they are functioning as expected, and to achieve this the physical environment of the centre, principally the air temperature and humidity must be closely regulated and monitored.

The evidence in all the reports concerning the location, operation and management of data centres around the world, indicates the imperative to provision adequate and secure energy supplies for current and future centre demands. Even when there is adequate provisioning, there is an equal necessity to monitor the performance and health of the power subsystems distributing the power within the centre and the behaviour of energy consumers such as servers, to guarantee that all resources are operating within the envelope of constraints and limits for which they were designed. Violation of any constraint or limit may compromise the viability of the centre.

To achieve all of these objectives and to ensure that data centres are reliable, efficient and resilient to internal and external adverse conditions and circumstances, requires the integration of information technology and facility management systems into a centralized control structure with intelligent capacity planning of a data centre’s critical systems. *Data Centre Infrastructure Management (DCIM)* are the systems in a data centre that provide this centralised control structure.

*Data Centre Infrastructure Management (DCIM)*

DCIM is a relatively new concept that many vendors are now using to cover their tooling for lifecycle management of a data centre. It crosses over the facilities management (FM) and the information technology (IT) functions – which is both its greatest and weakest strength.

In the Gartner model, the primary components of a DCIM solution are Input, Process and Output. Various sensors and other system feeds (Building Management System [BMS], user input, etc.) comprise the *input*. This raw data then sent through an analysis *process* to create actionable data — real information which can be used to manage the data centre. The processed data is then presented as *output* to the user, perhaps in the form of a dashboard or trend graph, and is also used as control data back into the input component.

*Input*
*Process*
*Output*

The 451 Group a leading global, syndicated research, advisory and professional services firm specialising in data centre technologies and developments, model breaks down DCIM into functional blocks, with data collection at its base. The data is used as input to the other functional areas, including Asset and Change Management, Environmental Monitoring, Power and Energy Measuring and Modelling, Power Management and IT Service and Systems Management. A data management layer integrates data from the lower layers to facilitate reporting as well as providing input to higher level planning, forecasting and optimization layers.

*Key similarities*

While the DCIM models vary in many ways, there are some *key similarities* found in each:
– DCIM provides actionable data for data centre management
– DCIM requires instrumentation in order to gather data centre metrics
– DCIM is not a standalone solution, but is instead a component of a comprehensive data centre management strategy.

## 2 The Need for DCIM in the Data Centre

In the lifetime of a data centre, it has to be designed, operated and monitored and the experience of its operation used to inform decisions for its future development and provisioning. We will discuss what role DCIM plays in these processes.

### 2.1 ROLE OF DCIM IN THE DATA CENTRE

The processes in a data centre can be divided into five phases. In each phase the DICM provides the information, see Figure 1.

*Design phase*

In the *Design phase*, DCIM provides key information in designing the infrastructure, power, cooling and network data at the rack level help to determine the optimum placement of new servers. Without this information, data centre managers have to rely on guesswork to make key decisions on how much equipment can be placed into a rack.

*Operations phase*

In the *Operations phase*, DCIM can help to enforce standard procedures for operating the data centre. The number of physical constraints and limits on operating both IT and facilities equipment is complex and enormous. Racks must not exceed the capacity of the PDUs supplying them otherwise a sequence of events culminating in a major outage may occur. Moving one server to another rack may unintentionally temporarily remove a vital service. The operation phase enforces standard procedures and alerts any anomalies or procedural violations.

*Monitoring phase*

In the *Monitoring phase*, DCIM provides operational data, including environmental data (temperature, humidity, air flow), power data (at the device, rack, zone and data centre level), and cooling data. In addition, DCIM may also provide IT data such as server resources (CPU, memory, disk, network). This data can be used to alert management when thresholds are exceeded, reducing the mean time to repair and increasing availability. There can be some degree of automation associated with monitoring such as automatically increasing cooling in hot-spot regions that have been detected. For mentoring to be comprehensive, it has to include, apart from the I.T equipment, all facility power, environmental control and security subsystems and IT room management.

The facility power management subsystem provides detailed insight into the status and operation of the entire electrical distribution network (from utility feeds, to transformers, to PDUs, to racks) within a building, often including the data centre. Electrical engineering staff and consultants utilize this subsystem to manage the electrical distribution network.

Facility environmental control subsystems traditionally support the requirements of corporate facilities departments. In addition to facility heat, ventilation, and air conditioning (HVAC) control, facility environmental subsystems can also encompass fire systems, water, steam, and gas systems.

*Security*

For users and providers of data centre facilities, security in a data centre is a major concern. It must be reliable and provide robust safeguards against a range of potential human and cyber attacks. Optical video management systems, biometric identification, and remote management systems become more widely available, traditional card-and-guard security is being supplanted by facility security subsystems that can provide positive identification and tracking of human activity in and around the data centre.

IT room management subsystems monitor the power and cooling systems on the IT room floor so as to maintain the uptime of servers, communication equipment, and storage equipment. Data centre IT room management subsystems are developed around the needs and requirements of the computer room operators (a need for faster speed and real-time information). The IT environment is characterized by frequent changes, intelligent devices, and a management approach resilient to change and unexpected events.

*Predictive Analysis phase*
*Key performance indicators (KPI)*

In the *Predictive Analysis phase*, DCIM analyzes the *key performance indicators (KPI)* from the monitoring phase as key input into the planning phase. Capacity planning decisions are made based during this phase. Tracking the usage of key resources over time, for example, can provide valuable input to the decision on when to purchase new power or cooling equipment.

*Planning phase*

In the *Planning phase* DCIM can be used to analyse 'what if' scenarios. Planning tools ensure that there is efficient deployment of new equipment and tracks assets within the data centre. Planning also involves simulation of potential changes in order to analyze the future impact on the data centre and its capacity to meet SLAs and any other functions and requirements. All planning takes place within the context of the business objectives of the data centre and guaranteeing that it can deliver them. This covers facility asset and capacity management enabling scheduling of upgrades and replacements of the power and cooling infrastructure. The planning phase is also responsible for the IT room asset and capacity management concerned with the optimal placement of racks, servers and the cooling and power subsystems.

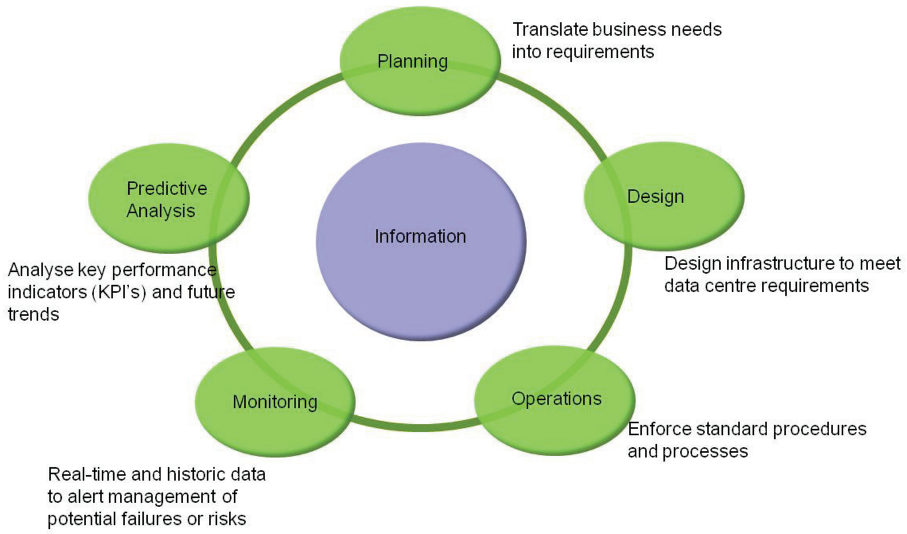


FIGURE 1 The Role of DCIM in the Data Centre

The dynamic nature of a data centre, its daily routine of providing computing facilities to an eclectic set users and clients, the variability of climatic conditions, the upgrading and replacement of all types of equipment, and the constant drive of the management team to improve performance and reduce operating costs conforming to a business strategy, implies that DCIM is a continuous, iterative process that is constantly being improved and upgraded itself.

## 2.2 DCIM ARCHITECTURE

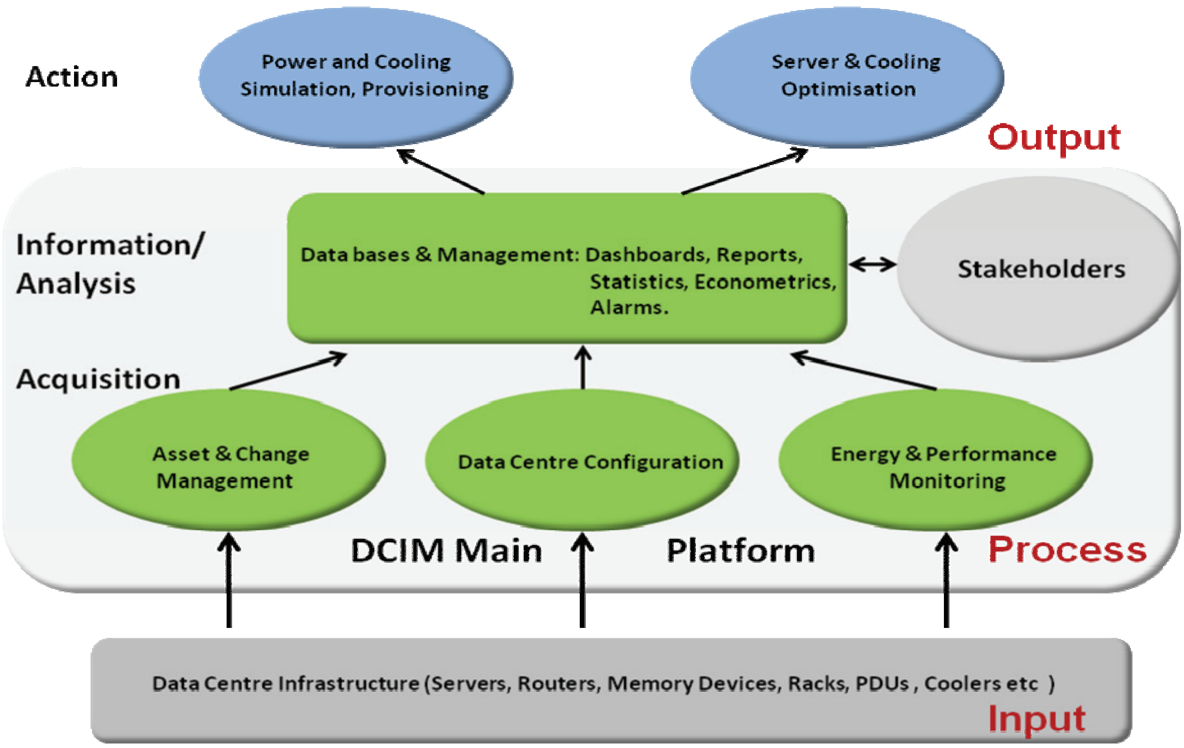


FIGURE 2 A Generic DCIM Architecture

*Input*

Figure 2 illustrates a generic architecture that can be applied to virtually every DCIM system. Data concerning the physical and operating conditions of the IT equipment, PDUs and CRAC systems is acquired and stored in one or more data bases. This forms the *input* of the DCIM platform. These are monitored via an array of sensors mostly in real-time by the Energy and Performance Monitoring unit. The physical infrastructure of the data centre is defined and recorded by the Data Centre Configuration Component, while any changes are handled by the Asset and Change Management component.

*Processed*

The data is then *processed* to produce a broad range of reports and dashboards for the numerous Stakeholders in the data centre. In some cases, the data can be used in simulation packages to analyse the physical behaviour of various aspects of the centre such as air-flow and heat distribution. Depending on the interests and responsibilities of these stakeholders the DCIM platform should be capable of delivering the appropriate information. For the following main stakeholders, the platform should provide the following type of information (the *output*):

*Output*

*Return on investment ROI*

– *Senior Management*: Graphs, Reports and dashboards on KPIs relating to general centre performance such as uptime/downtime, energy costs and trends, Service level performance and *Return on investment (ROI)*.
– *Financial Manager/Director*: KPIs and trends on operational costs concerning servers, CRAC systems and usage of data centre space. ROI statistics on major investments. Aggregated views of servers in terms of customers or cost centres. Quantifiable evidence of the economic advantage/disadvantage of the energy or capital investment strategy of the organisation in the data centre.
– *Operations Manager*: Reports, Dashboards and alarms of the behaviour of individual servers, PDUs or CRAC units. A lot of this information is required in real-time.
– *Technicians*: Specific and restricted access to a sub-set of the information accessible to the Operations Manager.

### 2.3 THE VARIETY OF SOFTWARE TOOLS IN DCIM

The multiplicity of users, each with their own responsibilities, priorities, preferences and agendas, implies that no single package will address all their needs. Furthermore, in a typical data centre there is a legacy of software systems which have committed users to various software solutions which cannot be easily changed or replaced. Despite the complexity of these systems, their use of open protocols facilitates ease of interfacing them to other packages. Overall, this means that while various DCIM vendors suggest that they can provide a unified monitoring and management solution, in reality there is not a single source of tools addressing all issues. Most DCIM systems are an amalgam of several disparate components that co-exist and collaborate through a common interface and set of protocols

### 2.4 TYPICAL QUESTIONS ADDRESSED BY DCIM SYSTEMS

An example of the sort of fundamental, operational or strategic questions that these stakeholders may enquire from a comprehensive DCIM system and expect to readily get a response are:
1 Where is a certain data centre asset located?
2 Where is the best rack to place a new server?
3 Do I have sufficient space, power, cooling and network connectivity to provide my needs for the next 6 months? Next year? Next five years?
4 If a certain adverse event occurs in the data centre can it be detected, what services are impacted and where should the technicians go to resolve the issue?
5 Do I have underutilized resources in my data centre?
6 Will I have enough power or cooling under fault or maintenance conditions?

The DCIM platform can carry out passive actions such as simulating the effect on the centre based on data that it has historically acquired or active where actual physical intervention is taken by the DCIM system such as increasing cooling in an area which has been identified as a hot-spot. Active intervention requires careful consideration and a much more developed external interface between the DCIM platform and physical environment, compared to those systems which merely alert and high-light events that require human intervention in the management of the centre's physical integrity.

### 2.5 GENERAL DCIM FEATURES

This list discusses the functionality and features of the wide range of software components that may be integrated into a DCIM platform. Since the complexity of DCIM systems installed in a data centre is discretionary, the number and combination of features in any platform is very varied.
– Basic data centre asset discovery – the capability to create an inventory of what already exists within a data centre facility, from servers, storage and networking equipment and other network attached systems, through to more manual capabilities of adding facility systems such as power distribution units, uninterruptable power supplies (UPSs) and chillers.
– Advanced asset information – systems should include databases of equipment and their real-world energy requirements.
– Granular energy analysis at CRAC, PDU, Rack and server level.
– Detailed reporting – Dashboards should be capable of providing different views for different stakeholders.
– Computational fluid dynamics (CFD) – Today's data centres are prone to overheating, and it is important to ensure that cooling is applied effectively. CFD enables analysis of air flows to be made and for this analysis to show where hotspots are likely to occur.
– 2D and 3D data centre schematics –These schematics show floor plans and the 3-D architectural structure of the data centre.

– Structured cabling management Information – many data centres, particularly those with raised floors, rapidly lose any structure to their cabling, as long cables are used where shorter ones would do, and any extra length is either looped or just pushed out of the way. Such lack of structure is not just messy, but it also impedes air flows,
– Environmental sensor management – Environmental data is essential to the monitoring and management functionality of the DCIM.
– Event management –In response to anomalous or threatening events such as excessive rack power demand a DCIM system can generate an alarm for the event, notify staff and possibly trigger a corrective response
– 'What if' scenario capability – Using historic data the effect of modifications to the server population, data centre cooling environment or power systems can be predicted or simulated.

Although there is no 'typical' DCIM system, even the simplest DCIM platform would have in most cases the following basic functionality:
– Asset inventory management.
– Change management.
– Low resolution power and energy monitoring e.g. CRAC, PDU and partial rack visibility.
– Dashboards and reports to supplement the Inventory and Change management and energy monitoring tools.

## 3 Making the Business Case for DCIM and Determining the Return on Investment

The three main drivers of investment in DCIM software are economics (mainly through energy-related savings), increased availability, and improved manageability and reliability. Making the business case in any commercial organisation is justifying any human or capital expenditure in a project, on the basis that it is economically or commercially beneficial. For instance, investment of €1000 to upgrade a machine may be justified in that it pays dividends in terms of improved reliability and increased production. The "Return on Investment" (ROI) metric is a measure, over a projected time-frame, where rates of return on money invested in an economic entity are evaluated in order to decide whether or not to undertake an investment. ROI has been explained in more detail in chapter 5. Unfortunately, the perception of many businesses is that the data centre is a necessary cost centre rather than a producer of business value. With this narrow attitude, spending on any item in the centre, including DCIM, has to be justified primarily on a financial basis, particularly as costs and maintenance of such systems can be in the region of €10'ks or €100ks. A more enlightened view takes into account other benefits and advantages which can ultimately be articulated into financial gains. For DCIM to be fully appreciated and utilised to maximum effect, all users and beneficiaries need to be engaged in the planning and installation phases of DCIM into the organisation concerned, and its full potential needs to be recognised from the perspectives of all stakeholders while it is still in the concept or development stage.

### 3.1 FOUR PART METHODOLOGY FOR TOTAL VALUE PROPOSITION

*Competitive advantage*

Quocirca [1] have devised a four-part methodology that produces a Total Value Proposition (TVP), a concept for establishing a business case and value proposition for the Individuals using DCIM tools, the Organisation in which the DCIM tools are being installed, the *Competitive advantage* and the Return on Investment (ROI). In more detail, the four parts are:

1 *Stakeholders/Users*: DCIM will automate many processes, requiring fewer man-hours to manage the centre. Upgrades can be scheduled and accomplished faster and with less error, since a full physical inventory of all servers exists and can be checked for compatibility before being installed. Thus the centre can deliver a better quality of service with fewer human and physical resources. Other inefficiencies can also be identified. These can be quantified in terms of money and time saved.

2 *Organisation*: Businesses with DCIM can respond to customer demands more swiftly and with lower risk of loss of service and outage. The value to the organisation of DCIM should be assessed in terms of value creation, risk mitigation and cost control. All of these factors can also be expressed in a financial context.

3 *Competitive Advantage*: By adopting DCIM, the benefit that this confers on the organisation in the delivery of its core business, over competitors who do not adopt should be considered and vice versa. Similarly, the scenario where both simultaneously do or do not adopt should also be evaluated.

4 *Return on Investment/ Scorecards*: The top ten processes or costs in the data centre which are affected by the data centre in the organisation should be assessed in terms of the anticipated increase or decrease in cost of executing them. A simple scorecard approach for each process is only necessary, where 1 denotes a large cost reduction and 5 a large cost increase. An average overall score less than 2 implies that DCIM adoption should proceed, a score over 4 implies that DCIM adoption should proceed only if it essential for the stakeholders, the organisation's survival or to maintain competitive advantage. Scores between 2 and 3 indicate that the ROI will be medium to long-term.

REFLECTION 1

What is meant by 'DCIM adoption should proceed'?

### 3.2 FUNCTIONS OF THE DCIM SYSTEM

It is apparent in the preceding analysis that the DCIM benefits are assessed in terms of their immediate impact on the centre and also on the organisation's ability to fulfil its business objectives and obligations outside of the centre. Sometimes the actual functional components of DCIM, how they influence or measure KPIs, and how this links directly to significant aspects of the business may also be analysed. Figure 3 illustrates the actual functions of the DCIM system and their correlation to the improved status of the business. This may be more appropriate for logistical or operational analysis, whereas the more economics orientation of the former method is more financially attuned. Both are of equal validity.

| IT Operation | DCIM metrics: IT | DCIM metrics: Shared | DCIM metrics: Facilities | DCIM Analysis | Business Benefit |
|---|---|---|---|---|---|
| Capacity Management | Rack space | Floor area | Power consumption | Future capacity requirements; predicted spend on energy. | More accurate forecasting for CAPEX and OPEX; |
| | Network bandwidth | | Cooling requirements | | |
| | Storage space | | | | |
| Service Delivery | Availability | Mean time to failure (MTTF) | Power availability | Business downtime; performance against agreed SLAs; | Greater productivity; higher user/customer satisfaction |
| | Recoverability | Mean time to failure (MTTF) | Power chain resilience and redundancy | | |
| | Planned downtime | | | | |
| | Catastrophic failures | | | | |
| Resource Management | IT equipment energy Efficiency (ITEE) | Carbon usage effectiveness | Temperature | Energy, carbon and water usage. . | Greater eco-competiveness |
| | Data centre infrastructure Efficiency (DCIE) | Water usage effectiveness | Coefficient of performance (COP) | | |
| | IT equipment utilization (ITEU) | Power usage effectiveness | Air flow Energy Star rating | | |
| Asset Management | Deployed hardware utilization ratio (DH-UR) | | Physical location; Volume of assets | Effective usage of assets | Informed procurement decisions; |

FIGURE 3 Assessment of DCIM Impact on a Business

### 3.3 BUSINESS PERCEPTIONS AND MOTIVES DRIVING DCIM ADOPTION

An Uptime Institute Survey in 2012 [10], see Figure 4, interviewed senior management in several hundred data centres to ascertain the main motives behind their initiatives to install DCIM platforms.
The survey indicated that the two main motivation factors driving adoption were:
1 Power, Cooling and Capacity Issues (Capacity management): Most common motive for reviewing and introducing DCIM tools.
2 Data centre consolidation (management of assets): Consolidation is focussed on maximising ROI on capital investment and reducing operating costs. This is only successful if the decision process is informed from data on server and facilities usage generated by various DCIM tools.

In their survey[6] in 2012, the Gartner Group discovered that the main issues influencing the adoption of DCIM tools in their sample, were slightly different. They were:
1 Provisioning for new data centres: Constructing a data centre without due regard to adequate instrumentation and monitoring would be very short-sighted and lead to significant costs and challenges at a later stage if retrofitting of the centre to address monitoring deficiencies was decided.

2 Technical and architectural changes: Technical upgrades, particularly those affecting power or cooling must be analysed. For instance, replacing ordinary servers with high-power blades will impact the power and cooling at their rack locations. Many DCIM tools can simulate the impact of these changes
3 Environment and sustainability agenda: Reducing the energy and carbon footprint of a centre is economically sensible and enhances its green and sustainability credentials. DCIM tools are vital in promoting, managing and validating a centre's authenticity and sincerity on its green agenda

*Operational*
*Financial*

Both surveys are equally valid and suggest that the main reasons for DCIM adoption are for *operational* and *financial* purposes, and that environmental considerations are largely secondary to them. The report further stated that unless organisations understand the logic for these decisions, DCIM systems will not be installed and their full benefit will not be realised.
Other recommendations made in the report are:
– DCIM tools should be included in the designs for all new data centres, as retrofitting is very costly and problematic.
– DCIM tools should be used to validate vendor's specifications and determine actual power consumption of devices.

*Key stakeholders*

– In any DCIM installation *key stakeholders* who will take responsibility for its installation, deployment and evolution must be identified.

*Corporate Social Responsibility*

– DCIM should form a key aspect of any *Corporate Social Responsibility* (CSR) initiative.
Companies that show CSR are striving for equilibrium between People, Planet and Profit and consider social, environmental and economic issues, see Chapter 1.

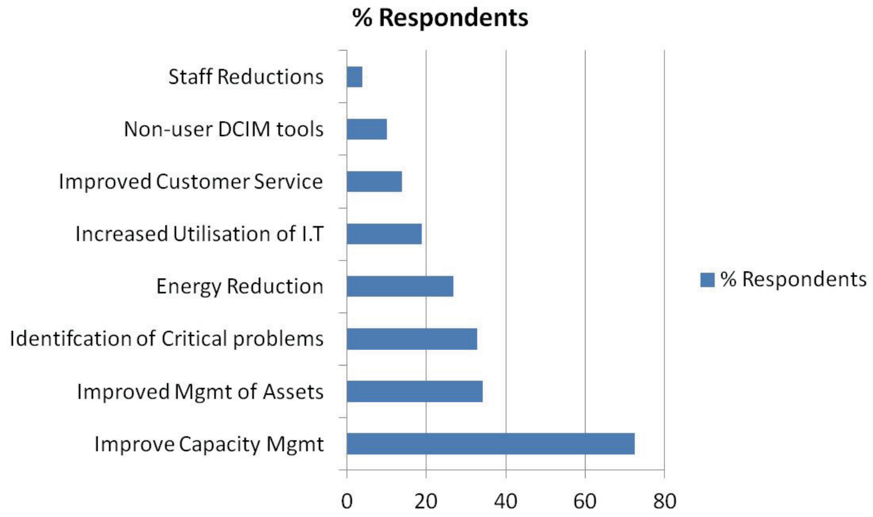


FIGURE 4 Primary Reasons for Investing in DCIM

The results of these surveys also suggest the priorities and business angle of attack that should be taken to successfully justify the deployment or adoption of DCIM to the broad data centre community.

It is also very informative to identify the reasons why despite the many apparent benefits of DCIM, there is still a large sector of the data centre market yet to be convinced . The Uptime Institute survey investigated the reasons and perceived obstacles by the data centre community for their reluctance to adopt DCIM systems. These reasons are shown in Figure 5.

Figure 5. indicates both psychological/educational and technical barriers which are symptomatic of the data centre industry. DCIM tools are seen as not cost-effective and their expense outweighs any perceived benefits or savings. This conclusion is not borne out by numerous studies or experience. Badly installed or conceived DCIM systems are costly, ineffective and cannot be justified. However, the essential ingredient to avoid these circumstances and maximise the economic return on any DCIM investment, is training and education of data centre staff. Staff should understand data centre metrics, standards and best practices and have the knowledge to set targets and achieve them by sourcing and deploy the best DCIM tools for their requirements.

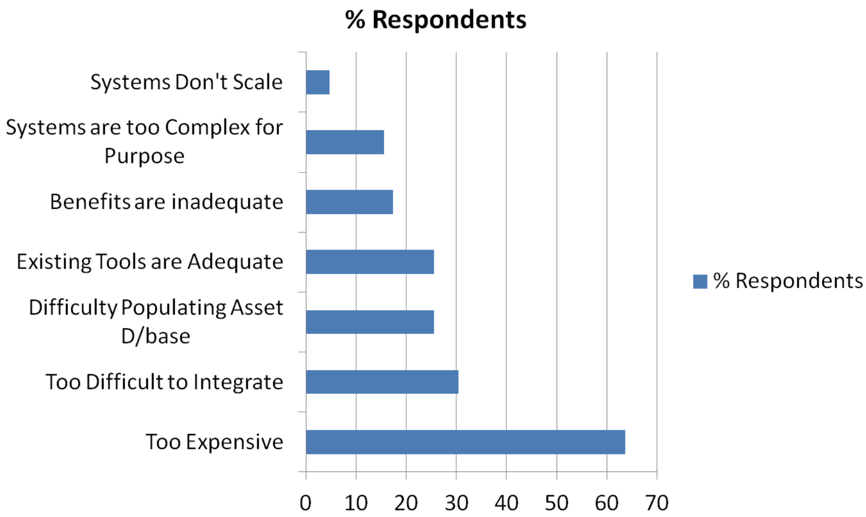


FIGURE 5 Primary Reasons for NOT Investing in DCIM

The other barrier is mainly technical and is due to the number of databases, tools and interfaces that must be taken into account in implementing a DCIM solution. In part this is a consequence of the infancy and evolution of the DCIM market, many components are proprietary requiring a list of licences and there is no 'out-of-the-box' solution yet. Fortunately, the DCIM market is consolidating and different tools are being amalgamated into single packages. Better knowledge on what is on the market, which is also an education issue, would also address this problem.

REFLECTION 2

What psychological/educational barrier and what technical barriers do you see in figure 5?

## 3.4 THE FIVE MAIN REASONS FOR THE FAILURE OF DCIM INSTALLATIONS

The previous section alluded to the misconception that does exist in many centres, that a DCIM solution is too complex and not cost-effective. This view is valid for cases where actual DCIM systems did fail for one reason or another, but it is wrong to attribute the failure to an intrinsic feature of DCIM systems. In 2012, the Data Centre Journal investigated a number of 'failed' DCIM systems and found that there were five main reasons for the failures and gave the following recommendations to avoid them:

### 3.4.1 *Lack of Planning*

Users should start with their specific business goals in mind. Define what your business needs are first, and then research possible solutions. Users want the benefits of the DCIM solution but don't take the time to define their specific needs. To gain the benefits of a DCIM solution, users must have specific goals in mind so they can measure success.

### 3.4.2 *Misrepresentation by the Vendor*

'Unfulfilled Expectations' occurs frequently in DCIM installations. Many technologies are new to the market and possess promising features that are not yet proven or in some cases even developed. If a company purports to do custom integrations or modules, make sure it has a standard process in place for handling these requests. Requesting details from previously implemented custom modules demonstrates a history of successfully meeting custom demands.

### 3.4.3 *Ownership of the Process*

Many companies outsource their DCIM implementation to a third party. Some of these third-party companies are competent, but others try to accomplish the work as a secondary item to their primary goal (e.g., some other software system, hardware sales and implementation, utility rebates and so on). As a secondary effort, the goals and process of the project tend to be less focused, and at times, the delivery of the product is not what was expected by the end user.

### 3.4.4 *Misconceptions of Upkeep Costs*

Even with a turnkey installation provider and implementation vendor, DCIM requires dedicated, assigned resources to be successful. Too often a system gets fully installed but never quite accomplishes the goals that were set because there are no user resources allocated to manage and maintain it. Another misconception of upkeep costs is underestimating total cost of ownership (TCO). Remember, from Chapter 5, TCO quantifies the financial impact of deploying an IT product over its life cycle and includes its energy cost, which is usually the biggest factor and additionally other costs like installation, licencing, maintenance and support. In the case of DCIM, some of the the benefits are difficult to quantify, for example, finding or locating computer assets with DCIM is very fast, but how much time or money does this save a company in a year ? Only if the value of DCIM is fully appreciated, will the reason for investing in and maintaining DCIM be understood

### 3.4.5 *Data Overload*

Too often DCIM systems collect so much data that the information that it is difficult to access. Projects with hundreds of thousands of data points are fine if the data can be correlated and communicated well within the DCIM system. Many users think they should collect every point of information they can—which can work in instances where the system is designed to intuitively communicate the important points.

## 4 Developing the Data Centre using DCIM: The Green Grid Data Centre Maturity Model

*Data Centre Maturity Model Equalizer*

In Chapter 2 we have seen that the Green Grid has developed the Data Centre Maturity Model (DCMM), which provides a road-map through incremental steps for improving energy efficiency and sustainability across all aspects of the data centre. DCIM tools are used in implementing and monitoring the various actions for each step. These improvements are detailed with reference to the major components of the data centre, including power, cooling, compute, storage, and network. The levels of the model outline current best practices and a proposed five-year roadmap for the industry. The DCMM provides capability descriptions by data centre area such that operators can benchmark their current performance using the *Data Centre Maturity Model Equalizer*, a chart which defines different levels of capability or functionality for the individual components, thus determining their levels of maturity and identifying the ongoing steps and innovations required as part of their data centre and IT strategy to achieve greater energy efficiency and sustainability improvements, both today and into the future. The following link gives the complete Green Grid DCMM matrix.
www.thegreengrid.org/en/Global/Content/whitepapers/~/media/Images/DCMM/DCMM_StandardE.pdf

The Green Grid defines Data Centre Maturity on a scale of zero to five:
– Level 0: Minimal/No progress.
– Level 1: Partial Best Practice.
– Level 2: Best Practice.
– Level 3 & 4: Trending toward Visionary.
– Level 5: Visionary

Analytics is fundamental for reaching levels four and five—where the greatest business value can be achieved—yet most organizations are still struggling to move beyond level one, due to the deficit of a stringent management strategy and plan for their data centre.

The initial levels chart the progress of a typical data centre that has taken no efficiency improvement measures to one exemplifying the state of an average data centre to one that employs current best practices. Levels 3 through 5 represent future capabilities toward which the industry should collectively move and innovate. An optimistic—but by no means prescriptive—timetable for achieving Level 5 maturity is five years.

The DCMM operates within the axes of Data Centre Efficiency & Sustainability and Investment (Financial, Time & Resource). These content areas align with the way many organizations are structured, which means that senior managers can easily separate the model into logical sections—Power, Cooling, Compute, Storage, Network, etc.—and send their internal teams to the sections that most apply to them (power/cooling issues addressed by the data centre team, compute assessments and improvements handled by the server team, storage initiatives passed to the storage team, and so on). These existing teams can use the DCMM to *benchmark* their operations, inspire improvement, monitor progress, and continually advance.

*Benchmark*

The nature of the data centre is such that some of the goals in the DCMM content areas may not be achievable independently due to *interdependencies*. Airflow management and increasing temperatures are related. In order to increase temperature as per Level 3 to Level 5 of the Environmental section (Set point range at inlet conditions to IT equipment), a data centre would need to have air flow and temperature management in place. This would be achieved by implementing Level 1 and Level 2 of the Operational section—starting with configuring hot/cold aisles, filling floor gaps, optimizing tiles, installing blanking panels in the cabinets, and so on.

*Interdependencies*

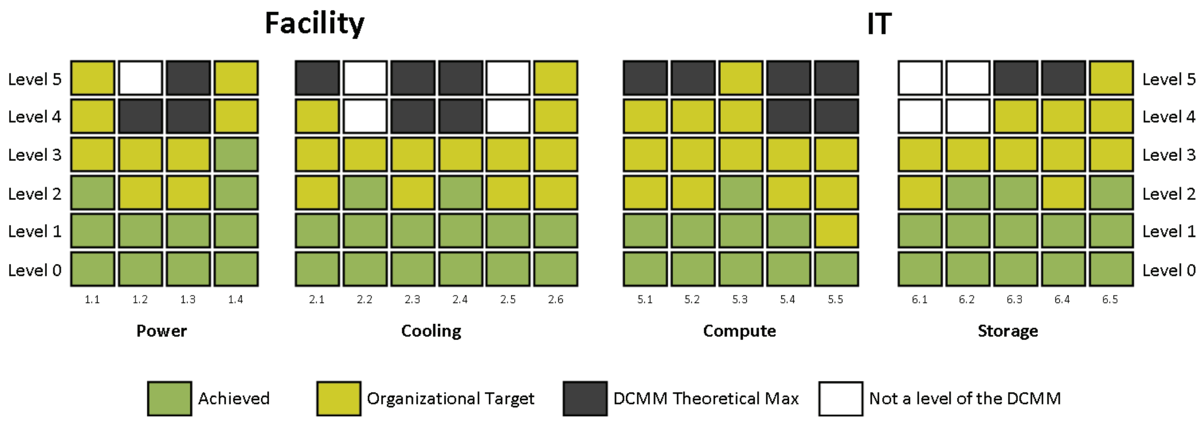


FIGURE 6 The Data Centre Maturity Model Equalizer indicating the Status of a Data Centre and a Proposed Route of Progression (Numbers 1.1, 1.2 etc refer to specific components in their respective categories)

The DCMM objective is to use data centre assets more effectively, thus reducing both capital and operational expenditures, as well as minimizing the centre's environmental impact and improving its corporate/social responsibility credibility. Data centre owners/operators and senior managers can use the DCMM as a tool for direction, self-assessment, and informed decision making. It serves as a compass indicating a series of routes which lead to best practices and beyond and a roadmap for the industry in general.

REFLECTION 3
How does the four part methodology described in Section 3.1 (making the business case for DCIM) relate to the DCMM model.

## 5 The Real-Time Monitoring Interface in the DCIM Environment

DCIM tools cover a broad spectrum of functions across the data centre. Many physical parameters, temperature, air-flow, humidity, energy consumption and other conditions such as security enforcement need to be continuously monitored in real-time. In most cases, the physical infrastructure equipment, HVACs, PDUs can provide all this information through data streams using standard interfaces and protocols that communicate with some portal or channel in the hub of the DCIM infrastructure. In some cases the information, such as server power consumption, can be acquired without additional hardware or wiring, but through proprietary agents installed on servers or other IT equipment which communicate over the internet.
Information acquired through standard interfaces and protocols are readily integrated into the DCIM fabric but attention should be given to practical issues such as the amount of wiring and cabling that may be associated with it, particularly if the interfacing installation necessitates downtime. Interfacing requiring only deployment of agents (usually written in Java) onto servers, circumvent all of these issues but concerns may arise over the extensive distribution of agents into the computing eco-system.

REFLECTION 4
Give comparative advantages and disadvantages of software and hardware based monitoring systems.

There are three categories of real-time monitoring systems that have particular importance for DCIM platforms. They are:
– *Building Management System (BMS)*
A BMS is typically a hardware-based system utilizing Modbus, BACnet, OPC, LonWorks or Simple Network Management Protocol (SNMP) to monitor and control the building mechanical and electrical equipment. These are often custom-built systems priced on the number of individual data points being monitored (a data point might be the output load on a UPS or the return temperature on a computer room air conditioner unit). In some cases, the BMS system is extended into the data centre to monitor and control power and cooling equipment.
– *Network Management System (NMS)*
An NMS is typically a software-based system utilizing SNMP to monitor the network devices in the data centre. Network devices can usually be auto-discovered, so installation can be automated to some degree.
– *Data Centre Monitoring System (DCMS)*
A DCMS can be hardware-based and/or software-based and is used to monitor a data centre or computer room. Device communication is typically done using SNMP, although some data centre monitoring systems can also communicate using Modbus, IPMI or other standard protocols.

There are some important attributes to consider when evaluating the real-time monitoring capabilities of a DCIM solution. One of the key considerations is deciding which devices are intended to be monitor. Solutions which only work with one vendor's specific equipment as you will then need to purchase multiple disparate systems to monitor your entire data centre should be avoided. Ideally, a DCIM system should be designed to work with a variety of 'Off-the-Shelf' hardware and software modules and applications.

In any real-time monitoring situation involving a hardware component, the number of sample points and associated hardware components should be carefully considered together with the price of each component. What may seem as a simple and feasible objective e.g. monitor the power consumption of each server, may in practice become prohibitively expensive when the unit cost of the measuring device is multiplied by the vast number of units that may be required and the man-power required for the installation.

One additional attribute to consider is whether or not the system supports auto-discovery of devices. Auto-discovery provides many benefits, including faster, easier installation and less chance for user error in manually configuring a device.

REFLECTION 5

What should be one of the main criterion used in determining the number of units and cost involved in monitoring ?

## 6 The DCIM User Interface

*Web-based*

DCIM user interfaces vary widely in both their look and feel and their overall capabilities. This is a natural consequence stemming from the manner in which DCIM systems are introduced and evolve in a typical data centre, and the eclectic number of users and stakeholders with a vested interest in various specific and selected areas of the information content in the DCIM platform. While most DCIM products are *web-based*, allowing access to the data from anywhere, the user interfaces can take many forms, including dashboards, touch screen technology, and application support for hand-held devices such as iPads and smart phones.

A good DCIM solution will provide some type of integration with external systems, ranging from loading Excel spreadsheets to direct database interaction to sophisticated web-based API (application program interface) which might allow the data to be passed both into and out of the DCIM solution and for customised daily, weekly or monthly reports to be generated.

In general, for DCIM platforms to deliver on their promise to create a centralised control structure which integrates information technology and facility management systems so as to facilitate intelligent capacity planning and optimisation of a data centre's critical systems, the user experience should be encouraging not perplexing and lead to easily identifiable actions for improved performance or operation.

This can only be achieved through continuous proper and adequate training of staff and key personnel in the centre in conjunction with user interfaces which should comply with the following guidelines:

*Intuitive*

– The user interface should be intuitive so users can quickly navigate through alerts, review environmental levels and review other detailed analytics specific their interests and responsibilities. This usually means that users should be engaged and their opinions and interests solicited when dashboards and reports are being designed.

*Customizable*

– Dashboards and reports should be customizable so that views of real-time data relating to mechanical, power, cooling and electrical usage etc contain actionable information not just data.

*Summarised*
*Drilled-down*

– Due to the normally massive amount of data in a DCIM platform, information should be summarised but with the ability to be 'drilled-down' if more detailed information is warranted.

DCIM is only part of the overall management solution. While the DCIM tools, or sometimes a suite of tools working together, are a valuable component, a complete management solution must also incorporate procedures which allow the DCIM tools to be effectively used.

## 7 A DCIM Case Study

Consider the following two data centres looking to purchase a DCIM solution.

*Data Centre A*
Data Centre A has a lot of older, legacy equipment which is being monitored using an existing BMS. The rack power strips do not have monitoring capability. The management staff currently tracks assets using spreadsheets and Visio drawings. The data has not been meticulously maintained, however, and has questionable accuracy. The primary management goal is getting a handle on the assets they have in the data centre.

*Data Centre B*
Data Centre B is a new data centre. It has new infrastructure equipment which can be remotely monitored through SNMP. The racks are equipped with metered rack PDUs. The primary management goals are to (1) collect and accurately maintain asset data, (2) monitor and manage the power and cooling infrastructure, and (3) monitor server power and CPU usage.

### 7.1 REQUIREMENTS OF THE DICM

While both data centres would likely benefit from DCIM, they may very well choose different solutions. The goal for Data Centre A is to more accurately track the assets in the data centre. They may choose to preload the data they have in spreadsheets and then verify the data. If so, they will want a DCIM which will allow them to load data from spreadsheets. If they feel their current data is not reliable, they may instead choose to start from ground zero and collect all of the data manually. If so, loading the data from a spreadsheet might be a desirable feature but is no longer a hard requirement. Since the infrastructure equipment is being monitored using a BMS, they might specify integration with their existing BMS as a requirement for their DCIM.

Data Centre B has entirely different requirements. It doesn't have existing data in spreadsheets, so they need to collect the asset data as quickly and accurately as possible. They may specify auto-discovery as a requirement for their DCIM solution. In addition, they have infrastructure equipment which needs to be monitored, so they will want the DCIM to be able to collect real-time data down to the rack level. Finally, they want to be able to monitor server power and CPU usage, so they will want a DCIM which can communicate with their servers.

Prior to choosing a DCIM solution, they should spend time determining what information is required to manage their data centre. It should start with the primary *management goals* such as increasing availability, meeting service level agreements, increasing data centre efficiency and providing upper level management reports on the current and future state of the data centre. Next, they should determine *what is needed* to accomplish these high level goals. The type of questions they might ask are:

*Management goals*

*What is needed*

– What data do I need to measure availability?
– What data do I need to measure SLA compliance?
– What data do I need to measure data centre efficiency?
– What data do I need to forecast capacity of critical resources?
– What data do I need for upper level management reports?

These questions begin to define the scope of the requirements for a DCIM solution. As they start to narrow down the focus of the questions, they will prompt more specific DCIM requirements. For example, if there is a requirement for the DCIM to provide real-time monitoring this may initiate a line of further enquiry. For instance:

*What is meant by 'real-time' data?*
Real-time data might mean thousands of data points per second with continuous measurement. Alternatively, it might mean measuring data points every few minutes or once an hour. There is a vast difference between a system which does continuous measurement and one which measures once an hour. In the absence of knowing the purpose for the data it is impossible to what is the appropriate solution. A solution will be chosen which will not necessarily provide the data granularity and which maybe over engineered and overpriced.

*What data centre equipment do you want to monitor?*
The scope of what is to be monitored really defines the size and complexity of the challenge. If it involves only major equipment units such as PDUs, HVACs with which the DCIM and data centre equipment communicate using SNMP and other equipment which communicates using Modbus, then providing the DCIM platform can handle both protocols the number of communicating devices is relatively small. Alternatively, If the DCIM system must retrieve detailed server information, it might be necessary for the DCIM solution to communicate using IPMI and other server protocols with a enormous number of devices.

## 7.2 IMPLEMENTING THE DCIM SOLUTION

DCIM typically requires some level of vendor support in the installation and configuration of the solution. This can range from simple installation support to thousands of man-hours of effort to collect asset information and configure the solution. Some DCIM solutions are highly customized, providing a very specific solution but often at a steep price. It is important to factor in the effort and cost of implementation when looking at the overall cost of a DCIM solution.
There are two primary efforts involved with implementing a DCIM tool:
– Collecting asset information
– Configuring real-time monitoring

### 7.2.1 *Collecting Asset Information*

The cost is often overlooked or under-estimated. Gathering the asset data is often as much as or even more than the cost of the management system itself.
Data centres can contain thousands of servers, power and cooling devices, and storage and network devices. The task of collecting data about each asset, particularly when starting from scratch can be very onerous. The typical cost to have an outside company collect 'readily visible' data (manufacturer, model, location, serial number and device name) is $15 per device. For a data centre with 8,000 assets, the initial data collection of basic data would be $120,000. Collecting this data by one of the centre employees would take approximately 40 man weeks of effort.
Even existing gathered data, may not include important configuration information required to properly manage the devices in the data centre. For a server, this information may include the hardware configuration (processor, storage, and memory), network connections, virtual machines and installed software and services. Collecting this information is much more difficult, involving logging. For 8,000 servers, collecting this data could cost $600,000 or require 200 man weeks of effort.
Depending on the modus operandi employed in assembling the asset data, other factors need to be considered. Manual tracking with pen and clipboard, or even spreadsheets is time consuming and highly error-prone. Organizations can typically expect a 10% error rate in manual data entry due to typing and transcribing errors.' In a data centre with 8,000 assets, a 10% error rate would mean that as many as 800 could have inaccurately recorded data.
There are DCIM products and complementary solutions which address the manual entry of asset information. These systems range from Radio Frequency Identification (RFID) solutions which track the location of assets to auto-discovery solutions which automatically collect detailed device data. These systems can significantly reduce the time and cost to collect the asset information as well as improving the accuracy of the data and providing support for auditing efforts.

### 7.2.2 *Configuring Real-Time Monitoring*

The real-time monitoring components provided by many DCIM solutions also require configuration before they can begin to collect data. SNMP is the most often used protocol, but some DCIM tools can also communicate using Modbus, IPMI or other protocols. It is important to remember that all monitoring systems require some method of communicating with a device in order to retrieve data. While most new data centre equipment should provide some means of retrieving data and alarms, some legacy equipment may not. Even new equipment may not provide the data communication components as a standard, which means you may need to purchase additional components in order to monitor the equipment.

When comparing DCIM real-time monitoring systems, priority should be given to those systems which work with a wide variety of hardware types (power, cooling, servers, etc.) from a range of manufacturers. There is constant flux of equipment migrating in and out of a data centre and it is important to future-proof any DCIM investment by ensuring it can communicate with a range of standard protocols. A DCIM solution should provide a single pane of glass view of the data centre, so avoid tools that only monitor one vendor's specific hardware. As with asset management, some DCIM solutions support auto-discovery of devices, providing a faster, easier installation with support for new devices as they are installed in the data centre.

## 7.3 KEY AREAS OF INTEREST WHICH SHOULD BE INVESTIGATED AFTER THE DCIM INSTALLATION

When the DCIM system has been installed and validated, there are some operational areas of the centre which should be investigated as early as possible as some immediate benefits can be derived with comparatively little effort using the incisive analysis that is characteristic of a well-designed system. This analysis is in the area of energy efficiency and asset management and usually reveals the 'low hanging fruit' in the centre, suggesting various actions in which savings can be easily gained and making an instant return on the investment.

### *7.3.1 Improved Energy Efficiency*

The information provided by DCIM can help data centre managers in reducing energy consumption:

*Matching supply with demand*
Oversizing is one of the biggest roadblocks to energy efficiency in the data centre. One of the primary factors for oversizing is the lack of power and cooling data to help make informed decisions on the amount of infrastructure required. DCIM solutions can provide information on both demand and supply to allow you to 'right-size' the infrastructure, reducing overall energy costs by as much as 40%.

*Identifying underutilized servers which could be decommissioned, repurposed or consolidated*
As many as 10% of servers are estimated to be 'ghost servers', servers which are running no applications yet still consume between 50-70% or more of the resources of a fully-utilized server. DCIM solutions can help to find these underutilized servers as well as servers which do not have power management functionality enabled, reducing IT energy usage as well as delaying the purchase of additional servers.

*Measure the impact of infrastructure changes on overall energy efficiency*
DCIM tools can measure energy efficiency metrics such as Power Usage Effectiveness (PUE), Data Centre Infrastructure Efficiency (DCiE) and Corporate Average Datacentre Efficiency (CADE). These metrics serve to focus attention on increasing the energy efficiency of data centres and to measure the results of changes to the infrastructure.

### 7.3.2 *Improved Availability*

DCIM solutions can improve availability in the following areas:

*Understanding the relationship between devices*
A DCIM solution can help to answer questions such as "What systems will be impacted if I take the UPS down for maintenance?" It does this by understanding the relationship between devices, including the ability to track power and network chains. This information can be used to identify single points of failure and reduce downtime due to both planned and unplanned events.

*Improved change management*
When investigating an issue, examination of the asset's change log allows problem managers to recommend a fix over 80% of the time, with a first fix rate of over 90%. This reduces the mean time to repair and increases system availability. DCIM systems which automate the change management process will log both authorized and unauthorized changes, increasing the data available to the problem manager and increasing the chances the issue can be quickly resolved.

*Root cause analysis*
One of the problems sometimes faced by data centre managers is too much data. Disconnecting a router from the network might cause tens or hundreds of link lost alarms for the downstream devices. It is often difficult to find the root cause amidst all of the 'noise' associated with cascading events. By understanding the relationship between devices, DCIM solution can help to narrow the focus to the single device — the router, in this case — which is causing the problem. By directing focus on the root cause, the problem can be resolved more quickly, reducing the associated downtime.

# 8 The Genesis and Evolution of the DCIM Market

## 8.1 EVOLUTION OF THE DCIM MARKET

The DCIM sector is still very much in its infancy, having origins circa 2010 in modified software packages developed by main-stream asset tracking companies for the data centre market. Global Sales of DCIM tools was $245M in 2010, and is growing at 39% CAGR (Compound Annual Growth) and will reach $1.3 B in 2015, see Figure 7. It is predicted that DCIM will become more main-stream, growing from 1% penetration of data centres in 2010 to 60% in 2014. A more recent assessment of the DCIM by the 451 Group has revised upwards the size of the market with predictions that the global DCIM market will reach €1.8 Billion by 2016 with a CAGR of 44%. A typical data centre costs $500m + to build, and an estimate by one of the largest power unit providers Emerson (www.emerson.com) puts the global number of data centres at over 500,000 and the number of servers worldwide is estimated to be over 35 million (2006) . It is not surprising with these numbers that the DCIM market is still largely untapped with less than 10% of mid-range data centres (<3 MW) having deployed DCIM.

Spending on 'Green' data centre measures, which will impact significantly sales of DCIM tools, is expected to triple from 2012 to 2016 to $45 Billion globally. Green spending will grow by 27% CAGR in Europe and U.S, 30% in Asia and the Pacific.

There are approximately 55 companies operating in the DCIM sphere. The 3 largest are Emerson, Nlyte, and Schneider with 45% of the market (i.e. 45% of $621 million). 30 companies have revenues less than $3 million. This suggests that there is still room for consolidation.

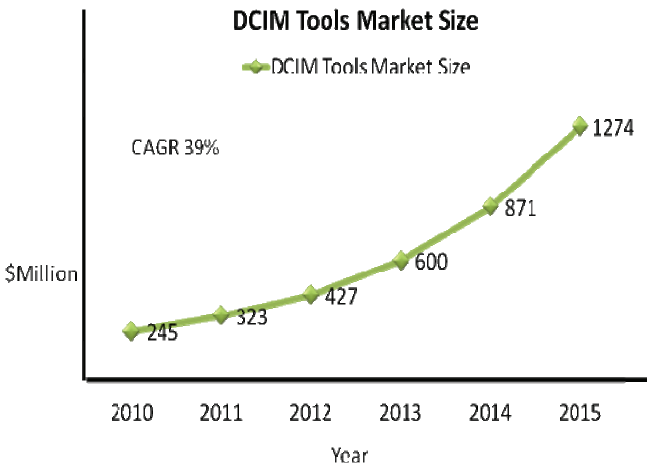


FIGURE 7 The Expanding DCIM Market

## 8.2 MATURITY OF DCIM AND THE MARKET

DCIM tools and platforms available today (2013) can be classified into categories according to their level of maturity expressed in terms of their functionality. This analysis produces a maturity model of the market. Each level in the hierarchy is dependent on the functionality of lower levels. The 5 levels in this maturity are shown in Figure 8 and defined as:
– *Level 1 Basic*: Basic monitoring mainly supplied with equipment. Some rudimentary asset and energy analysis with point tools.
– *Level 2 Reactive*: Some degree of integration between environmental monitoring and control of cooling.
– *Level 3 Proactive*: Extensive asset tracking and change management systems. More advanced monitoring systems can identify areas for greater power and space efficiencies.
– *Level 4 Optimising*: Extensive range of integrated IT and infrastructure tools leading to enhanced service management, predictive server workload analysis and elementary real-time optimisation of the servers.
– *Level 5 Automated, Self Optimising*: The DCIM system automatically adjusts in real-time the operation of the data centre according to rules, data loading and SLAs in order to maintain optimal performance.

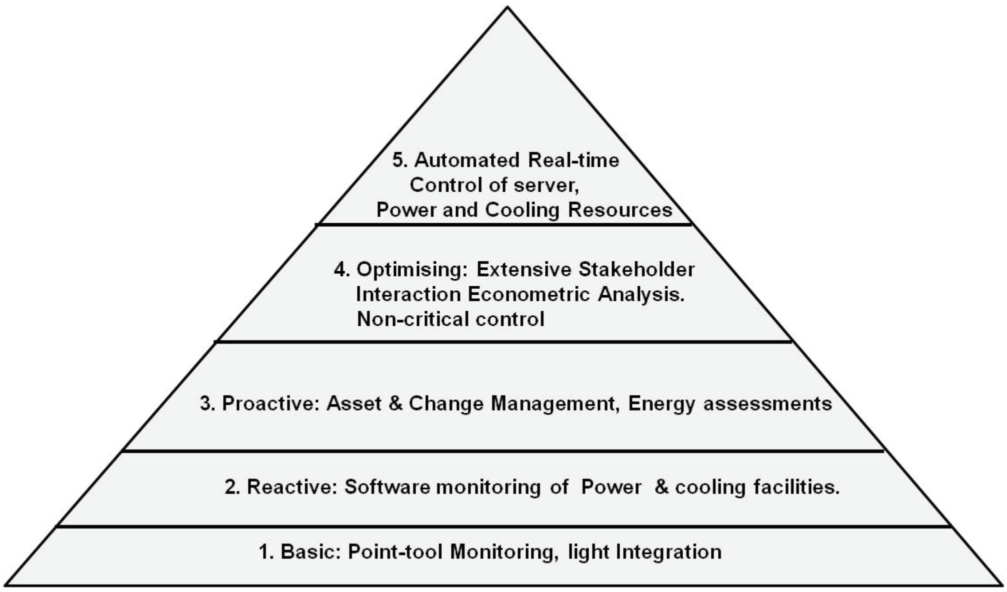


FIGURE 8 The DCIM Maturity Model

REFLECTION 6
Is there a connection between DCMM and the DCIM Maturity Model ?

The maturity model apart from being a taxonomical method for classifying DCIM tools, also serves as a road-map for the evolution of the DCIM market. Like any evolution process different systems and data centres are more advanced than others in terms of what has been achieved. A review of the market penetration of tools and platforms into the data centre market by the 451 Group in 2012, shows that DCIM adoption is still in its primordial state with over 90% of those centres with DCIM having level 1 tools, 90% of the level 1 population also have level 2 functionality (i.e 80% overall), but then for levels 3, 4 and 5 there is a big decline.

Only approximately 25% overall have Level 3, and this reduces to approximately 10% at Level 4 and 0% at level 5. See Figure 9.
Taking into account that only 10% of the entire DCIM market has been exploited , the evidence suggests that even where there is DCIM adoption, the vast majority of systems are quite elementary registering at Level 1 or Level 2.

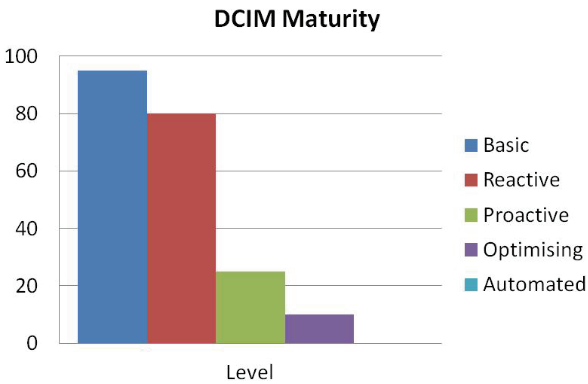


FIGURE 9 he Maturity of the DCIM Systems and Platforms that have been Installed

This clearly highlights the considerable scope that exists in the data centre industry to improve and automate their operations and increase efficiencies and productivity. As the DCIM tool vendor market consolidates no doubt the portfolio of products will reduce and become more integrated, so choice becomes simpler and installation more straighforward. Trends and best practice will also become more established, and hopefully data center staff and key personnel better informed and knowledgable. There are enormous business and commercial opportunities both for the DCIM vendors and users.

## 8.3 THE FUTURE

The global data centre market is growing in size at phenomenal rate. New business models and services are emerging on a continuous basis within the data centre industry it-self, by businesses which enable or support the data centre to deliver their services to their customers and clients. Then there are the businesses which are externa, most of the businesses with which we are familiar, that are dependent on on the cloud to conduct their enterprise. So with all of these factors and forces impacting on the data centre what is the future for DCIM. Some broad themes are emerging in the market:
– The data centre community is recognising that it has to become more professional with emphasis on training and adoption of best practices.
– The drive in data centres to increase efficiencies and automation of processes and tasks will increase DCIM investment.
– DCIM will become more integrated with IT services management.
– DCIM products will become more end to end and ‘Out of the box’.
– More automation will be introduced into data centres to reduce costs and manage customer demand.

## SUMMERY

The size and complexity of data centres has grown phenomenally over the past decade and they are now a core part of the global economic and social landscape. Managing and delivering many crucial and important services for industry and government is one key objective of a data centre but being a business it-self in a very competitive market, data centres are also concerned to conduct their business as efficiently as possible at minimal cost,while maintaining high standards and performance. All these targets and objectives can only be attained if there is a safe and reliable asset management system which tracks the current status of all IT and non-IT equipment and is able to provide all pertinent information associated with every asset item. This information will include details on the function, role or services being supported by the IT equipment; its location;the real-time operational situation such as power and cooling that is being demanded by the IT equipment and the current capabilities of the power and cooling facilities to fulfil it. Any potential threats that may infringe the integrity or functions of the centre must also be detected and where necessary action taken to pre-empt them. Related to all of these activities and tasks, there is an enormous, dynamic information flow generated by all the monitoring and management systems. The raw data from these systems must be translated into meaningful and insightful views for analysis and reports for numerous stakeholders in the centre charged with various key responsibilities and duties. The sub-system in the data centre which has been described and defined here is the DCIM platform. It is a composite system composed of several disparate hardware and software modules and units but all of which are an integral part of the DCIM platform, collectively they provide a centralized control structure with intelligent capacity and performance planning of a data centre's critical system. While assimulating the material in this chapter the following general questions are suggested for reflection:
– What is the range and type of data that needs to be constantly updated?
– What information that will be produced by the DCIM platform and for who and for what purposes ?
– How does DCIM transforms a data centre from a cost centre to a Producer of business value ?
– What are the driving forces behind the growth in DCIM deployments ?
– What are the obstacles to effective DCIM installations ?

*Literature*

[1] Longbottom, Tarzey: Building a case for data centre infrastructure management (DCIM). Quocirca, June, 2010.
[2] Brown, Bouley: Classification of Data Center Management Software Tools. White Paper 104, Schneider Electric, 2011.
[3] Gilbert, Ramakrishnan, Diersen: From Data Center Metrics to Data Center Analytics: How to Unlock the Full Business Value of DCIM. White Paper CA Technologies, April 2013.
[4] Nielsen, Bouley: How Data Center Infrastructure Management Software Improves Planning and Cuts Operational Costs. White Paper 107, Schneider Electric, 2012.

[5] Lane: Five Reasons Why a DCIM Fails. The Data Center Journal, November, 2012.
[6] Kumar: The Six Triggers for Using Data Center Infrastructure Management Tools. Gartner Report, February, 2012.
[7] Singh, Reuters: Data Center Maturity Model. The Green Grid, 2011.
[8] Cole: Data Center Infrastructure Management (DCIM). Data Center Knowledge, May 2012.
[9] Lawrence: The Evolution of Data Center Infrastructure Mnanagement (DCIM). 451 Research, September 2012.
[10] Stansberry, Kudritzki: Uptime Institute 2012 Data Center Industry Survey.

MODEL ANSWERS

**Answers to Reflection Question**

1 Any business makes an investment decision in anticipation that it will directly or indirectly improve its business performance, produce a number of benefits and ultimately make it more profitable and competitive. Typically, there are several options or proposals competing for limited resources such as personnel and finance in an organisation. Proposals which are essential or critical for the success of the organisation obviously have priority over those which improve performance or profit. The former must be executed whenever circumstances or funds permit. Outside of these critical choices, deciding or prioritising which actions or proposals should be taken is often a grey area. It is rather analogous to comparing the proverbial apples and oranges. If all outcomes and conferred benefits could be expressed in a common metric such as money, it would be a simple task. The decision on which proposal to execute would be the one which has the highest profit gain for the organisation. However, things are not that simple, some proposals may have immediate short term gains while others may lead to greater prospects for the organisation but take longer to deliver. In these situations, the decision is largely influenced on how visionary is the organisation by choice and circumstance. DCIM should definitely proceed if there is clear financial gain to the company in its main processes or costs (a score or 2 or less). The degree and urgency of DCIM deployment will be further influenced by the extent that benefits are felt across the organisation. This is the purpose of the other 3 parts of the methodology, As far as possible the benefits should be expressed financially since it makes comparisons very simple. However, effects on issues such as reputation and social responsibility are more difficult to quantify. These are all part of making the business case and estimating the return on investment and although it may employ a rigorous methodology, it should be remembered that there is an element of art as well as science in the process.

2 There is a growing body of evidence that substantial savings are possible in data centres that employ DCIM systems with trained and experienced staff. DCIM systems are cost-effective providing the appropriate system for the size and scale of the centre has been determined and deployed. Therefore, the major response that DCIM systems are too expensive, does indicate that the respondents have a fundamental misunderstanding of DCIM systems. This educational deficiency is also manifest in the other responses Benefits are in adequate and Existing tools are adequate. Whether this is a lack of training or a reluctance to train and change which is more psychological, it is impossible to know with this evidence. Scaling, Complexity of systems and Difficulty of integration have been recognised technical barriers to DCIM adoption which fortunately are now being addressed and resolved by many of the current tools in DCIM platforms.

3 The DCMM is largely a technical roadmap for the evolution of the data centre in an organisation. It sets functional and operational targets for the major components of the centre, power, cooling, computing etc. and defines the incremental paths that will guide the developments which will progress the centre towards these goals. In conjunction, with the technical incremental steps, there must be no loss of sight of the overall impact on the organisation at each step. This implies that the DCMM should be supplemented with the Four part methodology so that the business case for each incremental step can be assessed in terms of cost and benefits. Failure to do so, could lead to the technological advancement of the centre purely for the sake of technological advancement, while the real agenda should be one of investing in technology that shows real quantifiable cost-effective benefits for the organisation.

4 *Software-based*

| | |
|---|---|
| Advantages: | Easy to deploy (no wiring), No downtime, Easy to upgrade and less likely to fail. |
| Disadvantages: | Potential security threat in installation and operation, Non-standardised interfaces with proprietary agents, systems monitor mainly energy and power. |

*Hardware-based*

| | |
|---|---|
| Advantages: | Standardised Protocols/Interfaces, Large variety of devices for measuring the physical environment. |
| Disadvantages: | Cabling required and possibly downtime for installation, Higher costs, Human installation |

5 This is really another type of business case question. Some monitoring is essential for security and reliability of service so that they are completely justified expenditures in an organisation. Introducing or enhancing other monitoring systems have to be economically justified on the basis on what are the benefits generated by the increased data flow or quality of data. Referring to Chapter 5 , Figure 5, increased monitoring should be judged on how it reduces the of size errors relative to each other. Improving monitoring to more accurately measure an entity of relatively minor importance e.g. PDU power loss (5% of power) should be given less priority compared to measuring IT equipment efficiency (40% of power)

6 The DCMM is a technological map with a compass directing efficiencies and sustainability in the centre through incremental advances. These developments will improve efficiencies and allow more control and a new range of operations and mechanisms to be applied throughout the centre. In the DCIM Maturity model, levels 1 and 2 in the hierarchy are composed of basic tools which monitor and report the status of the server, power and cooling systems. These are passive tools. Levels 3, 4, and 5 define tools which are more abstract, have more intelligence, and interact more strongly with key components in the centre. As a centre progresses through the DCMM landscape, more functions and interaction will be enabled in the centre which will act as a catalyst encouraging the creation of more tools in the upper levels of DCIM Maturity model.