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"Informative Design" – Personalized Elevators in the Information Age | "信息化设计" – 信息时代的个性化电梯

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Abstract | 摘要

Over the years, elevators have become faster, safer, more intelligent, and highly energy efficient. They are now a way of life, and their design is quite mature. We are now entering a phase of "Informative Design," where information is the new commodity that will drive efficiency and value. Smart phones and other portable communication platforms carried by the elevator user provide a rich source of information that may be augmented with additional sensors in the elevator to deliver a customized experience. In this paper, we describe some novel ways to enhance safety, convenience, personalization, and efficiency for the riding passenger. Benefits include seamless dispatching with minimized wait times, security and safety during transit, and a customized experience. We also describe the use of remotely accessible sensors on the elevator to improve the reliability of the elevator and enhance the experience of the building manager.

Keywords: Connected, Customized experience, digitalization, Elevator, Informative Design, Personalized experience

多年来，电梯速度越来越快、更安全、更智能，而且非常节能。大众生活离不开电梯，电梯设计已经相当成熟。我们迈入"信息化设计"阶段：信息成为新的商品，不仅提高效率，而且创造价值。人们在搭乘电梯时携带的智能手机和其他移动通讯平台，形成富信息源，结合电梯内的其他传感器，提供定制化体验。本文中，我们介绍一些为乘客带来更安全、便捷、个性化体验和更高效率的新方法。带来不少益处，其中有：无缝调度（尽量缩短等待时间）、运输过程的保障和安全及个性化体验。我们还介绍了如何利用电梯内的远程传感器，改善电梯可靠性，改善楼宇管理员的体验。

关键词：互联、定制化体验、数字化、电梯、信息化设计、个性化体验

Information: Enabling a Return to People-Centric Design

Many innovations have an initial effect of reducing product or service quality (Calantone et al. 2006). However, a key benefit of breakthrough innovations is that they introduce new dimensions for product merit. Over time, the new attributes introduced by "game changing" innovations become dominant, and former key success factors become less significant (Christensen 1997). The vertical transportation industry has seen several distinct architectural generations, from Elisha Otis' introduction of human-safe elevators, to the comfort and elegance of birdcage elevators manned by skilled human attendants, to the lower cost and efficiency of button-controlled elevators, up to the latest destination dispatch systems. Each step-function change in architecture, sustaining, and component innovations enabled evolutionary refinement (Henderson and Clark 1990).

As an example, consider the introduction of automatic elevator systems, which essentially marked the beginning of the end of human operators. Behind the mechanical buttons

信息化：设计回归以人为本

许多创新最初会降低产品或服务质量（Calantone 等人,2006 年）。创新突破的一项关键好处在于，这些创新突破让人们可以从多个维度了解产品。随着时间推移，颠覆性创新带来的新特性逐渐成为主流，而过去的成功要素已无足轻重（Christensen，1997 年）。垂直运输业历经数代重大构造革新，从 Elisha Otis 推出的人类安全电梯、娴熟电梯操作员操控的鸟笼式电梯（舒适、优雅），到更低成本并更高效的按键式电梯、再到最新的目的地调度系统。持续的结构和部件创新会推进产业进步（Henderson 和 Clark，1990 年）。

例如：自动化电梯系统推出后，标志着电梯操作员退出历史舞台。机械按钮和开关的背后是继电器逻辑的改善，实现添加调度、多轿厢协调及轿厢满员后不停站通过楼层。电气/电子控制系统进步后，才实现上述先进功能。30 年后，微处理器系统诞生，不仅降低成本，而且改善可靠度，能执行早期轿厢对齐等复杂控制算法。然而，上世纪早期十分普遍的礼貌、预期、个性化服务现已完全绝迹。

and contactors, improvements in relay logic enabled the addition of scheduling, multi-car coordination, and floor bypass when a car was full. These advances were all based on advances in electrical/electronic control systems. Microprocessor systems, appearing three decades later, reduced cost and improved reliability which enabled the implementation of complex control algorithms, such as Early Car Assignment; however, the courteous, anticipatory, personalized service that was ubiquitous in the early part of the century was now virtually extinct.

The commercial and regulatory underpinnings of the industry have driven a focus on providing functional parameters, such as system availability, efficiency, and emergency evacuation per local codes and standards. The enormous competitive pressures of the industry have resulted in less attention to passenger convenience and comfort as "optional" attributes of a vertical transportation system. As evidence, the research agenda of the CTBUH has eleven distinct areas; of these, only "Architecture and Interior Design" encompasses passenger experience, and then only tangentially as part of the overall building user experience (Oldfield, Trabucco, Wood 2014).

As a mature, highly regulated industry, there is significant commoditization. A key product differentiator may be in the loosely-defined arena of Passenger Experience. Attempts to improve passenger experience beyond the assumed experience improvement of faster elevators have resulted in features such as media, customized lighting, and aesthetic design. Beyond "environment," more recent innovations such as RFID access control, touch-panel COPs, or smartphone apps may generally be classified as "new buttons" – offering one-for-one replacement of means to access existing functionality (Figure 1). In the final analysis, aesthetic and button replacement solutions do not alter or improve the experience for the passenger. They only change the environment and the means of inputting commands – essentially a "skin" over an existing operating paradigm that has been remarkably unchanged in over 80 years.

We propose a framework for true advances in passenger experience, including new means of synthesizing a richer, more holistic perspective of operating environment, and incorporating latent capabilities of elevator systems tuned for speed and efficiency to respond to this more powerful perspective of users and their needs. The term, "Informative Design" is used to encompass both the information inputs ("Informative"), and the system response to those inputs ("Design").

Information and Interpretation

Much attention is paid to technologies coming online: communication and the increasingly common sensing capability of consumer devices such as smartphones, smart watches, and fitness trackers. While the present and anticipated future states of these technologies are dazzling, there is an ever-present risk of incorporating "technology for the sake of technology;" however, meaningful, delightful, game-changing solutions rely on thoughtful design (Vedin et al. 2006).

As an example of layering design on even the simplest of technologies for new user benefits, a delightful feature found in some vehicles is that the rear wiper, in addition to being directly operated by a manual switch, is automatically operated when the front wipers are on and the vehicle is shifted into reverse (Jones 1991). The inputs of "front wipers on" and "reverse selected" are binary, low-tech, and extant. However, thoughtfully using "what is known" (wipers on, reverse selected) feeds interpretation of "what this means," (the former datum means, "It's raining," and the latter means, "What's behind me is suddenly important") leading to "what to do" (IF it's raining AND driver needs rear visibility, THEN turn on rear wipers).

行业出于追求效益和符合规定的目的，逐渐按当地规范和标准，提供系统可用度、效率和紧急疏散等功能参数。行业承受巨大的竞争压力，因此不太注重乘客的便捷性和舒适度，将其视为垂直运输系统的附带特性。CTBUH 研究议程便是例证，共有 11 个不同领域。其中，仅有“构造和内部设计”涉及乘客体验，楼宇总体用户体验也就如此点到为止（Oldfield、Trabucco、Wood，2014 年）

作为成熟、严格管制的行业，商业化进程日新月异。产品间的关键差异可能就在定义不那么严格的乘客体验上。千方百计去改善乘客体验，而不是研发速度更快的电梯，因此媒体、自定义照明和美学设计等功能便应运而生。RFID 访问控制、触控屏 COP 或智能手机应用程序等新近创新，超越“环境”范畴，总体上可归入“新按钮”类别，对现有功能都有一一对应的替代控制（图1）。最终分析结果显示，美学和按钮替换解决方案不会改变或改善乘客的体验。上述方案只是改变了环境和输入指令的方式，其实换汤不换药，关键技术 80 多年来竟然未有改进。

我们提出一套架构，去真正改善客户体验，包括：采用全新方式，让运营环境更丰富、更全面，激发电梯系统在速度和效率上的潜能，满足用户对强大电梯技术的愿望和需求。“信息化设计”有两层含义：信息输入（信息化）以及系统对输入的响应（设计）。假设：电梯系统的客观性能必须不受损害，并认为：“信息化设计”预测乘客需求，能增强乘客体验和系

Figure 1. The evolution of the elevator passenger experience (Source: Otis)
图1. 电梯乘客体验演变（来源：奥的斯电梯公司）

In the world of elevators, RFID sensors or car weight sensors are like the wiper or transmission switches in the previous example – presently useful, but simplistic in effect. However, they could possibly be just two points used to synthesize a multidimensional view of the environment, the user, and their needs. Combined with additional, already available information (e.g. time of day, video analytics), and the hands-free indication of passenger proximity (RFID) may paint a picture of a passenger with impaired mobility outside of the morning up-peak. In response to this richer picture of the world, a feature such as increased door dwell time may be indirectly activated for enhanced passenger comfort in this specialized situation. The growth in the number of inputs is shown in Figure 2.

The focus here isn't the specific introduction of technologies – we can only assume these will arrive at an ever-increasing rate. Rather, the keys of Informative Design are:

- Integrating a wide and growing range of external sensors, devices, and databases with internal elevator capabilities;
- Fusing these inputs in increasingly insightful ways to build an awareness of the surrounding world, users, and their needs; and
- Activating existing capabilities, already compliant with appropriate codes and standards, possibly in new ways to provide new customer convenience.

Note that Informative Design doesn't preclude the introduction of new elevator system features; but elevator system designers needn't wait for new operating modes or functions to deliver the benefits of thoughtful, well-crafted custom experiences.

Informative Design for the Riding Passenger

This part of the discussion will focus upon experience of using the elevator, also known as Passenger Experience. The experience is focused on four key themes as depicted in Figure 3: Identification, Location, Intent, and Environment.

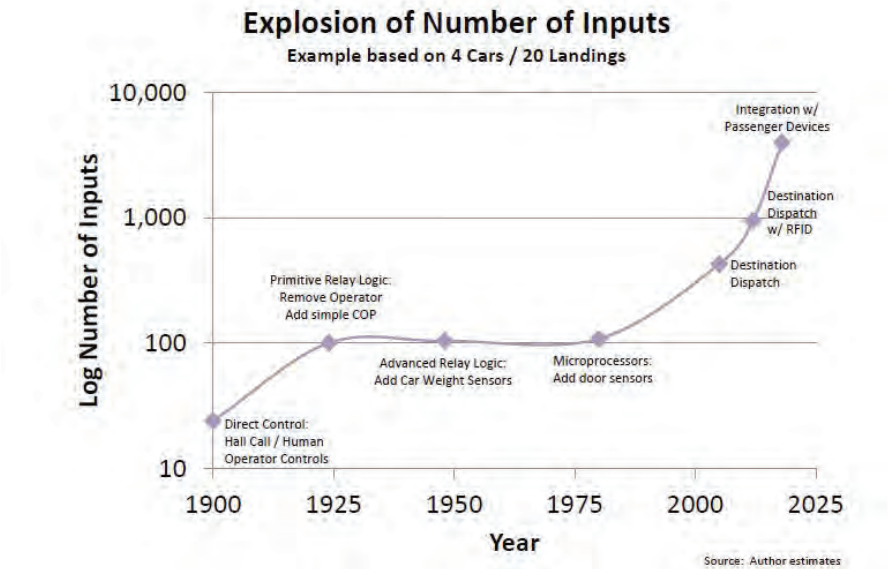

Figure 2. An explosion of inputs to the elevator system (Source: Otis)
图2. 电梯系统输入激增（来源：奥的斯电梯公司）

Figure 3. Four themes of the passenger experience (Source: Otis)
图3. 乘客体验四大主题（来源：奥的斯电梯公司）

统性能。假设众多，但终归是假设，需要去证实。我们注意到：信息化设计特性便于评估用户行为和系统响应。

信息与解读

大众更为关注在线技术：通讯和消费设备（例如：智能手机、智能手表和健身跟踪器）逐渐普遍的传感能力。尽管这些技术令人眼花缭乱、前景喜人，但始终有“为技术而技术”的风险；要知道，有意义、令人愉快和颠覆性解决方案要靠思维缜密的设计（Vedin 等人，2006 年）。

以分层设计为例，哪怕是为了让用户获得新益处而设计最简单的技术，部分汽车有了后雨刮器这项令人愉快的功能，除了能使用手动开关来直接控制外，打开前雨刮器并且挂倒档时，后雨刮器会自动运行（Jones，1991 年）。“打开前雨刮器”和“挂倒档”属于二元输入，没什么科技含量，至今仍在使用。但从思维逻辑来看，使用“已知操作”（打开雨刮器、挂倒档）来解读“含义”（前一数据表示：“正在下雨”，而后一数据表示：“后方状况突然变得重要”），从而“采取措施”（如果正在下雨，而且驾驶员需要了解车后状况，那么系统启动后雨刮器）。

在电梯领域，RFID 传感器或轿厢重量传感器就像上列中的雨刮器或变速箱档位，简单而有效。虽然，只是简简单单两个信息点，但能从多维度去审视环境、用户和需求。结合其他可用信息（例如：时间、视频分析），即使早晨上行高峰期之外移动能力受影响时，乘客近场（RFID）免提设备也能打印乘客照片。为应对更复杂状况，系统会间接激活增加电梯门驻留时间等功能，来增加客户舒适度。输入数量增长如图2所示。

我们不关心具体推出哪些技术，而是去假设技术推出的速度不断加快。更进一步说，“信息化设计”的关键在于：

- 把种类繁多且不断增加的外部传感器、设备和数据库与电梯内部功能结合；
- 以更具洞察力的方式来分析输入，逐渐了解环境、用户及其需求；
- 激活现有功能，符合适当的规范和标准，尽可能以新方式为客户提供全新便利。

请注意：“信息化设计”不会妨碍电梯系统新功能的推出；但电梯系统设计师无需等到新运营模式或功能向客户提供周全完善定制体验才了解功能效果。

1) *Identification* – the discernment of the identity of the individual, their access profile as defined in the security parameters set by the building decision makers, their needs, and their visit frequency.

2) *Location* – maintaining the exact location of the individual within the 3-D coordinate space of the building, including security zones, lobbies, and controlled and uncontrolled zones within the building perimeter.

3) *Intent* – learning when and where the individual wants to go to reach their intended destination.

4) *Environment* – engagement of the individual's senses with the building ecosystem, including elevators, to ensure the passenger is notified and understanding of their determined route.

The discussion will proceed to describe the most pertinent aspects of what, how, when, and where, with regard to the four themes.

Identification

The identification of the individual is the first and foremost need of a passenger experience. Are they an owner, tenant, regular visitor, building service provider, or a one-time visitor? Each has their own profile of access needs and permissions. In addition, does that person already have an established security credential permitting access, such that the transaction to simply verify the credential remains valid? If not, perhaps the person is just a one-time visitor for whom security permission is a one-time visitor pass created through a visitor management process. Then, through verifying the security credential, will this person have special needs such as: accommodations considered under the International Disability Alliance (IDA) to eliminate all entry barriers for people with disabilities, VIP privileges, or broad access for building services personnel (IDA, 2016)?

Various means of identifying individuals include human security forces at guard stations, secure ID cards, facial recognition systems, security cameras, mobile phone identity, and other means which are being created regularly through the infusion of new technology. The challenges are being faced and satisfied regularly through connecting various building sub-systems, such as security, HVAC, fire alarm systems, elevators, and other machine-based systems together. The security credential carried by the individual gains or denies them access based upon their recognized profile (Figure 4).

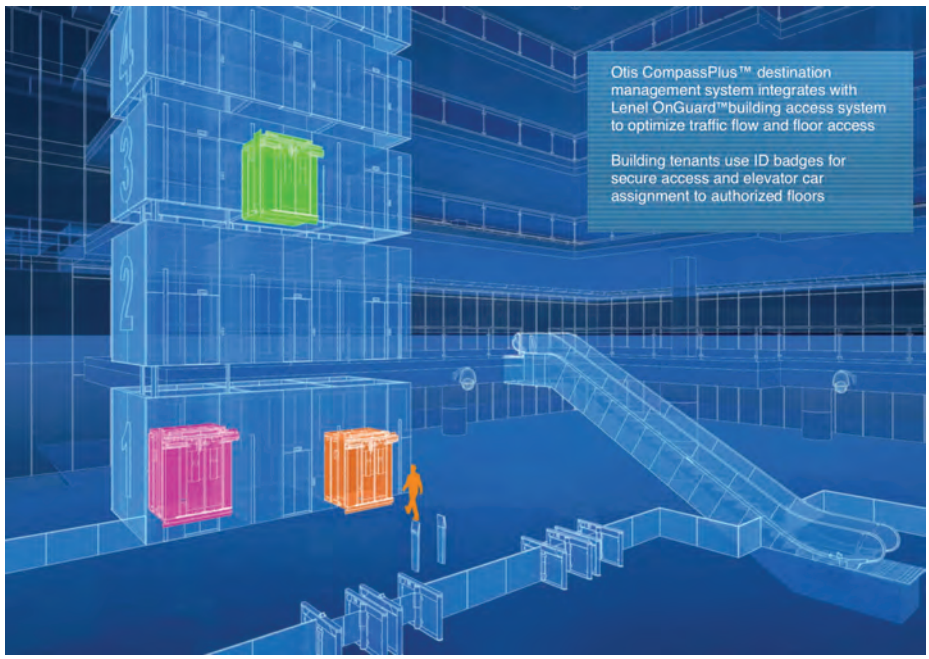

Figure 4. Access control in a destination management system (Source: Otis)
图4. 目的地管理系统中的访问控制示例（来源：奥的斯电梯公司）

面向乘客的信息化设计

本部分重点讨论电梯使用体验，也称之为“乘客体验”。体验重点分为图3所述的四大关键主题，即身份识别、位置、意图和环境。

1）*身份识别* – 识别行人的身份、根据楼宇决策者设定的安全参数判定访问情况、其需求及其造访频率。

2）*位置* – 在楼宇（包括安全区域、大堂和楼宇周边的受控和非受控区域）的三维（3D）坐标空间中获取行人的准确位置。

3）*意图* – 了解行人何时、何地希望到达其预期目的地。

4）*环境* – 让行人的感受融入楼宇生态系统，包括电梯，确保告知行人，使其了解预期路线。

讨论会深入描述最为相关的方面，如涉及四大主题的内容、方式、时间和地点。

身份识别

行人的身份识别是乘客体验的首要需求。行人是业主、房客、常客、楼宇服务供应商、还是一次性访客？每种人均有自己的访问需求和权限。此外，若该人已有规定的安全凭证，允许访问，则处理时是否只需简单查验凭证是否仍有效即可？若非如此，可能该人仅为一次性访客，其安全许可由访客管理程序创建，仅供一次性访客通行。通过查验安全凭证，确定该人员是否有特殊需求，如是否按照国际残疾人联盟（IDA）的规定为残障人士消除了所有进入障碍、是否具有 VIP 特权，或是否为楼宇服务人员放宽访问权限（IDA，2016 年）？

各种身份识别方式包括警卫点的人力安全队伍、安全 ID 卡、面部识别系统、监控录像机、手机身份识别，以及其他通过定期结合新技术创建的方式。将多栋楼宇子系统（如：安全、HVAC、火警系统）连接起来，挑战则可迎刃而解并达到满意效果。根据行人所持安全凭证的识别情况（图4）同意或拒绝其访问。

困难在于以全新方式使用该凭证，让行人对楼宇生态系统产生自然、直观和定制化的体验。身份识别之后可用于个性化选择：

- 选择电梯
- 视频显示器上的图像和信息内容
- 延长电梯门驻留时间，以便走入电梯
- 用智能手机自动唤梯
- 尚未提及，甚至不敢想象的多个其他方面！

位置

行人难以在楼宇内进行 3D 定位，但随着时间的推移，定位变得越来越现实和准确。有些产业联盟，如 InLocation，由 50 多家公司合作，共同创建新标准和协议，促进无线技术发展，应对挑战，实现了对 10,000 或更多人，在楼宇 3D 空间内的室内定位（InLocation，2016 年）。其中必须考虑楼宇周边、楼宇内的安全地带、大堂，以及靠近电梯或电梯内区域，已定位的相同人员会进行移动。

人员、物体，如 ID 卡、智能手机和其他技术可在楼宇内进行跟踪，只要允许即可。部署多种方法必不可少，如：摄像机、定位指示信标、读卡器、警卫、十字

The challenge lies in using that credential in new ways to make the passenger experience natural, intuitive, and customized for the passenger and the building ecosystem. The identity can then be used to personalize:

- the choice of elevator;
- the images and information content on video displays;
- travel time by extending the dwell for walking to an elevator;
- automatically placing the elevator call from a smartphone;
- and many more unmentioned aspects, perhaps yet to be dreamed!

Location

The 3-D position of an individual within a building is quite a challenge, and becoming more realistic and accurate with time. There are industry alliances, such as InLocation, where more than 50 companies are working together to create new standards and protocols to enable progress of wireless technology to step up to the challenge of maintaining indoor positioning for 10,000 or more people within a 3-D space of one building (InLocation, 2016). Consideration must be given to the building perimeter, security zones within a building, the lobby, and proximity to or in elevators which move the very same people being located.

People and objects such as secure ID cards, smartphones, and other technology can be tracked through buildings, where permitted. Various methods are deployed such as cameras, locating beacons, card readers, security guards, turnstiles, and various other access points. Just as with mapping a journey to plan a route, the start and destination points are both needed. With elevators, location is considered to be the "From" or start of the journey. Learning the "From" is becoming an integral part of the building ecosystem, such that in the near future (if not already in some cases), the only need to map a journey will be the next topic of Intent. The location (or the "From") will be automatically discerned by the building ecosystem.

Intent

Learning the destination intent of an individual can be more challenging than locating them. Intent can be pre-registered, such as a known floor programmed within a security ID that only allows the holder to go to their authorized floor. It can be learned by pressing an elevator call button as has been done for many decades; and now, technology advancement is allowing wireless signaling of intent through a smartphone and perhaps even through computers and software. The challenge with pre-registering intent is the unpredictable behavior whereby humans spontaneously change their intended destination. Seemingly, there must be at least minimal signaling of intent in the form of verifying or canceling the predestined route. There is a delicate balance between convenience and system performance. Unfilled calls send partially filled or empty elevators needlessly to destinations. Intent can also be deciphered by motion sensing to understand when someone is actually walking to an elevator for usage as opposed to walking by to get through the lobby or even distinguish between someone entering versus someone leaving the elevator.

The overall objective through whatever combination of methods and technologies is to clearly learn and fill each passenger's objective of reaching their destination. Many modern buildings combine the security access control with the elevator system control to not only control access, but also to enhance the experience by using the knowledge within the security system to plan, enable, and control each individual's passage through the building system. Data from the security system is then passed to the elevator and used to place the call automatically for the holder of the security credential because the intended destination is known.

Environment

Identification, location and intent are clearly inputs to an elevator system. Learning, understanding, using, and storing those inputs of information enable the journeys to and through the building to the intended destination. Once those are known, the elevator assignment is made, and the experience of engaging the passenger senses becomes the primary objective. One new method of assignment and notification is displayed in Figure 5, using smartphones or smart watches.

转门以及多个其他入口。就如同筹划旅程以规划路线一样，既需要出发地，也需要目的地。使用电梯时，位置视为旅程的“出发”或开始。要在未来建立楼宇生态系统，就要了解“需求”，制定计划仅需了解意图，我们接下来就会讲解。位置（或“出发地”）可由楼宇生态系统自动识别。

意图

要了解行人前往的目的地比了解其所处位置还要困难。意图可进行预登记，比如将已知楼层编程在安全 ID 内，则持有者仅可进入获得授权的楼层。只需数十年如一日地按下呼梯按钮，即可获知。现在技术进步，已实现通过智能手机，甚至可通过电脑和软件发送意图无线信号。无法预测行为是预登记意图的难点，人们通常会自发改变其预期目标。表面看来，验证或取消预定路线时无太多意图。便捷性和系统性能间必须实现微妙的平衡。未乘梯的呼梯请求将特别满或特别空的电梯送达不必要的目的地。动作感应也可辨别意图，了解人们是真的走向电梯进行使用，或相反只是路过电梯到达大堂，或甚至可区分进入还是离开电梯。

方法和技术的完美结合，其整体目标是清楚地了解并满足每位行人到达目的地的目标。很多现代化楼宇将安全进入控制与电梯系统控制集合，利用安全系统中的信息，规划、实现并控制行人穿过楼宇系统的通道，既控制访问，又增强体验。因为预期目的地已知，安全系统中的数据传送至电梯中，并为安全凭证持有者自动呼梯。

环境

身份识别、位置和意图明显是电梯系统的输入内容。获知、理解、使用并储存这些信息输入，可完成楼宇物至预期目的地的行程。了解这些后，即可进行电梯分配，融入行人感受的体验成为首要目标。图 5 展示了一种利用智能手机或智能手表的新型分配和告知方法，

视觉概念进而通过地图和路线搜索进行分配、告知、娱乐、引导，并带来其他视觉舒适性，如报告新闻，以及在查看器屏幕中显示内容和图片（图6）。在全玻璃观光轿厢中有些人怡然自得，有些人则坐立

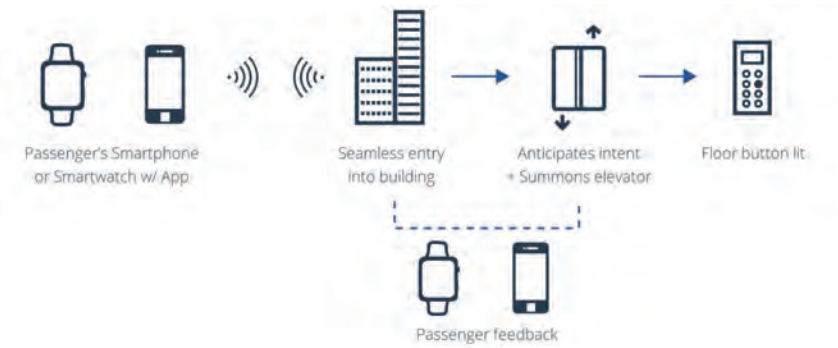

Figure 5. Informative design to provide a natural flow and intuitive experience (Source: Otis)
图5. 提供自然流动和直观体验的信息化设计示例（来源：奥的斯电梯公司）

Figure 6. Informative design to provide a personalized experience (Source: Otis)
图6. 提供个性化体验的信息化设计示例（来源：奥的斯电梯公司）

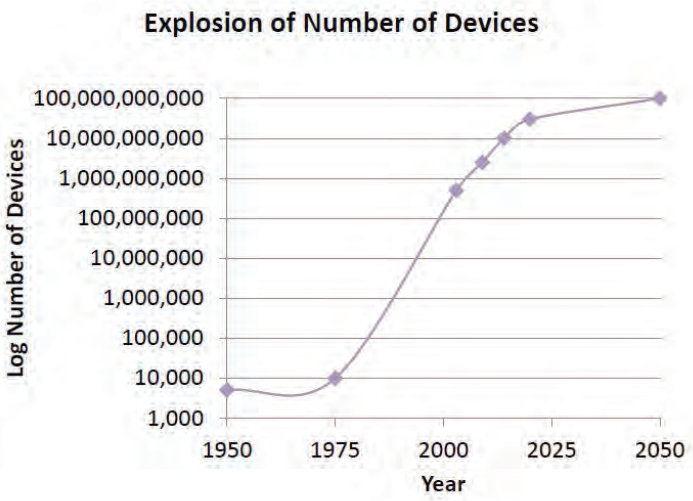

Figure 7. The explosion in the number of connected devices (Source: Otis)
图7. 连接设备数量激增（来源：奥的斯电梯公司）

Visual concepts then become to assign, notify, entertain, and guide passengers via maps and way finding, and provide other visual comfort such as reporting news or displaying content and pictures on viewer screens (Figure 6). Some are very comfortable in an all glass observation car, but others can get very upset in the same car, so the inputs can be used to steer a rider to or away from such a choice as part of their profile in the form of VIP or special services considerations.

Audible concepts include verbal guidance, such as for ADA accommodation, or enabling two-way communication.

Comfort or feel is the final consideration. Many feel more comfortable when there is little to no vibration during the elevator ride. A steady elevator that stays in one place while being loaded or unloaded enables people to feel less nervous. The speed of the acceleration and deceleration, as well as the movement of a car can either comfort or unnerve someone and the desired feel varies depending upon the culture.

In recent years, technology has enabled the addition of many enhancements to the passenger experience. Destination entry, whereby a person tells the elevator exactly where they wish to go before or upon entering it (rather than just signaling up or down), has brought many new aspects to the riding experience while seeking to attain the "no wait" elevator. The journey to the elevator assignment becomes part of the wait for the elevator, thereby reducing the passenger's wait in front of the shaft. LCD and other digital displays are now a regular feature on many elevators, not only to provide information pertinent to the journey, but also to entertain passengers. Wireless technology is also promoting new ways to facilitate the interaction between people and machines, making the machines much more utile and enhancing interface and interaction, enabling machines to operate more effectively thereby increasing the benefit to elevator users. Moving people through buildings no longer requires physical touch, as the passenger experience is becoming (through deliberate actions) increasingly more natural and personalized. The good news is that foreseen and unforeseen innovation will continue to focus on this experience, making it increasingly more effective, efficient, and desirable, all while being readily customizable.

Informative Design for the Building Owner

In an increasingly connected world (Figure 7), building owners and managers have a tremendous amount of data at their fingertips. Those customers crave information to better service their tenants, but do not have the time to go searching for it. Service providers need to understand what data creates value for the customer, and how they can help them optimize the efficiency within their buildings. Transforming data to information and delivering it, via tools like smartphones, requires a digital platform that includes Internet of Things (IoT) technologies, such as Connectivity, the Cloud, and Analytics. Let's take a deeper look into the components that will transform the value proposition to elevator customers.

不安，因此此种选择可输入 VIP 或特殊服务考虑事项中，用于控制乘梯者进入或避开。

听觉概念包括语音指导，如 ADA 调节或实现双向沟通。

舒适性或感受是最终考虑事项。电梯升降过程中极少震动至无振动范围内，会感觉更为舒适。上客或下客时，停留在一处的稳固电梯可减轻人们的紧张。加速度和减速度以及移动可让人感到舒适或紧张，预期感觉因文化而不同。

近些年来，技术使得乘客体验大幅提升。乘客通过目的地设定，在进入电梯前或进入时，告知电梯其准确目的地，而不是仅仅选择向上或向下信号，这实现了不同侧面的搭乘体验，力图实现“无候梯”电梯。电梯分配前的行程也纳入候梯部门，可缩短乘客的候梯时间。LCD 及其他数字显示面板现已是电梯的常规功能，不仅提供行程相关信息，还为同一乘客提供娱乐。无线技术也积极推动新方式，方便人机互动，让机器变得更为有用，促进两者的结合与交互，实现机器更高效运行，从何让用户更多受益。行人穿过楼宇不再仅是与周围环境进行物理接触，而且路人体验日益变得（通过刻意行为）更为自然和个性化。好消息是可预见和不可预见的创新将继续关注体验，使其日益更加有效、高效且满足要求，且可轻松定制。

面向楼宇业主的信息化设计

随着世界连接性的增强（图7，该图说明了设备的激增），楼宇所有者和管理者手头掌握了海量数据。这些客户希望信息更好地为其没有时间搜索的住户提供服务。服务供应商需要了解哪些数据为客户创造

Control, Connectivity & Cloud

There are unique challenges to connecting devices within an elevator hoistway. Imagine someone carrying a cellphone conversation across a lobby. You often hear the person on the phone announce they are entering an elevator and may lose connection. However, the explosion of smartphones and other connected products has forced network providers to continually improve their coverage, particularly in high-density areas, such as those within cities. Additionally, building managers are becoming more open to installing dedicated wireless networks and gateways to support the growing number of connected building technologies and an increasing amount of sensor data.

Sensors play a crucial role in Informative Design by providing visibility to the operating behavior and condition of the elevator (Figure 8). Existing sensors are utilized for the purpose of closed loop control, which enables everything from smooth door operation to the ability of the elevator to level with a landing. As the condition of an elevator adjusts over time, these control loops need to be adjusted to ensure for a consistently pleasant passenger experience. The sensor data used in these control loops can be collected and analyzed to drive control improvements for better fault tolerance and custom, installation-specific control needs. This data provides the key to identifying the root cause of deviations and drift from the smooth elevator operation that the passenger expects. New sensor technology is also being deployed with the intent to not only identify the root causes of failures, but also provide situational awareness, such as crowd control, and improve the efficiency with which the service technician can maintain the elevator.

As global connectivity infrastructure matures, new equipment manufacturers are shipping elevators with simple gateways to stream an unprecedented amount of data for service organizations to better understand the health of equipment in the field. In addition, low cost sensors can be added across the elevator subsystems to further enrich data collection. Although remote elevator monitoring has been available for three decades, the type and frequency of data has been constrained

价值，及其如何帮助客户优化其在楼宇内的效率。将数据变为信息，并通过类似智能手机的工具进行传递，这需要数字化平台，包括物联网（IoT），如连接、云技术和分析。让我们深入探讨一下为电梯客户转换价值主张的组成部分。

控制、连接与云技术

在电梯间连接设备面临独特挑战。想一想那些手持手机在大堂交谈的人。您经常会听到接听电话的人声明自己要进入电梯了，随后就会断线。但是，智能手机和其他连接产品的激增迫使网络供应商不断扩大其覆盖范围，特别是高密度区域，如城市内。此外，楼宇管理者也越来越愿意安装专用无线网络和通道，支持不断增多的连接楼宇技术以及越来越多的传感器数据。

传感器在信息化设计中发挥着重要的作用，使电梯的运行性能和状况清晰可见（图8）。现有传感器用于闭环回路控制，从平稳梯门运行到电梯性能，再到落客，能实现一切功能。随着时间推移，电梯的状况也在变化，这些控制回路需要进行调整，以保证为乘客带来始终如一的愉快体

Figure 8. The connected elevator (Source: Otis)
图8. 连接的电梯（来源：奥的斯电梯公司）

by technology. Today, those constraints are gone, leaving opportunity to reinvent the maintenance business. Once connectivity is established to the elevator, the next task is to store large amounts of data in an easily accessible, but secure place. Luckily, this is a primary use case for the cloud. Not only can the elevator controller send alerts when equipment fails, but they can also record performance data from the number of runs in a given period to when a door reversal occurs, providing a new stream of data on the health trending of equipment. Alerts and performance data can be streamed to the cloud and combined with other operational data, such as repair history, maintenance procedures, and service bulletins. Adding external data such as weather or traffic and even social media creates a big data opportunity that creates value through productivity and customer satisfaction.

Condition Based Maintenance

In traditional service models, maintenance is scheduled based on the calendar. It does not take into account the data previously mentioned that is becoming readily available via low cost connectivity and easily accessible via the cloud. This creates a change in the business model where equipment becomes more reliable at a lower service cost. No longer will wearable components need to be replaced before their useful life expires.

In the service business of tomorrow, condition-based maintenance will allow mechanics to perform the right tasks only when they are required. Planners will leverage data analytics and machine learning techniques to monitor the health of equipment and make predictions on the failures of specific components. Mechanics can be dynamically dispatched and armed with information on what tools, instructions, and spare parts to bring. Looking out over longer time horizons will allow mechanic routes to be optimized, reducing non-value added time, such as travel. Elevators will run better and longer without unplanned outages and service organizations will be more efficient and productive, creating a true win-win scenario based on use of advanced analytics.

Customer Communication

The new service model enabled by IoT (Connectivity, the Cloud, and Analytics) changes the way we maintain elevators. The use of technology allows services to be performed more efficiently, remotely, or even eliminates unnecessary tasks. This creates tremendous value for the customer; however, it creates a gap in the perception of the service performed. Building managers are used to seeing mechanics onsite. It gives them comfort that an expert is looking at and caring for their equipment. This human factor cannot be ignored as new technology is introduced.

Not only do the service organizations of tomorrow need to change their internal operations to leverage technology, but they also need to provide visibility to their customers on the service that is being delivered. Rather than a specific number of scheduled visits per year, customers are getting service around the clock, 365 days a year. Tools like dashboards or simple mobile apps will allow them to see the maintenance performed on their units, both onsite and remotely. Health reports can be posted and reviewed at their convenience. This can be integrated with existing service portals so customers can easily report issues and pay invoices. IoT is changing the way service is performed and perceived. No longer are customers in the dark about service. They are willing and able to accept new technology and are a critical part of the journey toward the service business of tomorrow.

Concluding Remarks

Elevator manufacturers are rapidly moving innovation efforts from their traditional domain of electro-mechanical design to a new space which is fueled by information technology and software. The commoditization and socialization of digital and communications technologies has enabled a generation of large amounts of information at low cost that may be harvested to enhance product offerings. Intelligent use of this information to anticipate needs and deliver value is the essence of Informative Design that will form the basis for the next generation of products. This paper illustrates some of the dimensions along with which Informative Design is being applied today. We are just getting started and this will be a rich area of innovation in years to come.

验。可搜集并分析这些控制回路中所用的传感器数据，促进控制改善，提高容错性以及针对安装的自定义控制需求。该数据可提供关键信息，识别导致与乘客期望电梯平稳运行存在偏差和偏离的根本原因。部署新型传感技术不仅旨在识别故障的根本原因，还希望提供态势感知，如人群控制，还能提高效率，维修技术人员可凭此对电梯进行维护。

随着全球连接基础设施日趋成熟，新设备制造商通过简单网关运行电梯，为维修机构提供了空前多的数据，可供其更好地实地了解设备的良性运转。此外，电梯子系统安装的低成本传感器也可进一步丰富数据收集。虽然远程电梯监控已使用数十年，但数据类型和频率均受到技术限制。如今，这些限制已消失，为维护企业的彻底改造创造了机遇。电梯具备了连接性后，其下一任务就是在存取方便的安全位置储存大量数据。很幸运，这是云技术的首个使用案例。当设备故障时，电梯控制器不仅可发出警报，还可记录性能数据，从特定时间内的运行量到出现门逆转，均可进行记录，为设备的良性运转趋势提供数据流。警报和性能数据会传送至云端，并与其它运行数据结合，如维修历史、维护程序以及维修公告。添加外部数据，如天气或客流，甚至社交媒体，创造大数据机遇，通过提高生产率和客户满意度创造价值。

按条件维护

在传统服务模式中，按日期安排维护。这种模式并未考虑数据，正如之前所提及的，借助云技术的低成本连接性和轻松访问能力，现已唾手可得。这促使业务模式发生改变，设备的维修费用更低，但可靠性却增加。耐磨部件直到其使用寿命终止才需更换。

在未来服务业中，按条件维护让机修工仅在必要时执行适当的任务。规划员会利用数据分析和机械学习技巧监控设备的良性运行，对特定部件的故障进行预测。机修工可进行动态派遣，并掌握所需携带工具、操作指南和备用配件的详细信息。长时间观察可优化机修工路线，缩短无附加价值的时间，如通行时间。电梯避免计划外停机，则可更好运行更长时间。维修机构利用先进分析，会更高效且更有成效，从而实现真正的双赢。

客户通讯

IoT（连接、云技术和分析）实现的新维修模式，改变了电梯维护方式。技术使用实现了高效、远程进行维修，甚至可避免不必要的任务。这为客户创造了巨大价值。但是，所提供服务的感知中存在差距。楼宇管理方负责现场查看机修工。专家照看并护理设备让其感到放心。引入新技术时，不应忽视这一人员因素。

未来维修机构不仅需要改变其内部运营，以利用新技术，还需要让其客户透彻了解其所提供的服务。与每年定期查看特定次数相比，客户可全年 365 天全天候享受服务。仪表盘或简单移动应用等工具让其可现场和远程观看其装置的维护。良性运行报告可在其方便时公布及查看。这可与现有服务门户结合，方便客户轻松报告问题和付款。IoT 正在改变提供和感受服务的方式。客户不再对服务一无所知。客户愿意并可以接受新技术，是打造未来服务业的重要部分。

结束语

电梯制造商对其创新工作进行快速转换，从传统的电子机械设计领域转变为新空间，由信息技术和软件进行推动。数字和通信技术的商品化和社会化，以低成本生成大量信息，从而增强产品供应。合理使用该信息来预测需求并实现价值，这是信息化设计的本质，奠定下一代产品的基础。本论文阐述了如今 ID 应用的范围。我们刚刚起步，这将成为未来数年的创新富集领域。

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