Biosensing mechanisms that detect electrical and IR signal is great potential, as they can bring down regular device costs and realize to unification in portable apparatus; nevertheless, the approaches to realizing minimum costs and high efficacy and selectivity vary and, to date, face several technical challenges (Berti and Turner, 2011; Kaushik et al., 2016; Song et al., 2016; Z. Sun et al., 2016b; Syedmoradi et al., 2017; Wisitsoraat et al., 2017; Xia et al., 2016; Zhang and Liu, 2016). Size contraction is another vital direction of research towards biosensor improvement, as it is essential for portability and convenience at the cellular scale. The miniaturization of biosensor devices, nevertheless, comes with two incompatible model requirements: they need to be both enormously small and immensely sensitive. As the sensors are made smaller, their surface area functions tend to diminish. The strength of the signal generated by a biosensor device is directly proportional to its surface area and tends to reduce as the structure of the sensors gets smaller. The background current of the biosensor also dwindles with the shape. Thus the challenge in miniaturizing sensors is to retain a signal to noise ratio that allows for productive and sensitive processing of the analyte. This necessitates coating the nanoscale sensing platform with a large density of biomolecules. The credible fabrication of thin, strong and highly energetic biosensing layers on small platforms and electrodes has posed a major barrier to the development of useful micro platforms and microelectrode biosensors.

Here, we propose the consideration of a newer biosensing scheme, where the reaction of biomolecular detection is not directly accountable for a current/potential shift, but rather acts as the trigger of a nano-materials phenomenon that is more precisely recorded. Such a scheme sequence event was identified without difficulty as a QCM biosensor based on GO, infrared spectroscopy biosensing based on GO, and a GO nanopore opening/closure.

5.1. QCM BIOSENSOR

The recent high-cost food recalls due to food poisoning bacteria (Valentini and Palleschi, 2008; Vastarella and Nicoastro, 2005; Willner et al., 2007) have increased brought to the fore the need for quicker, more sensitive and specific methods of detection of these microbial hazards, as conventional detection methods rely on time-consuming enrichment steps, followed by biochemical identification, requiring a total assay time of up to 1 week in certain cases. The rapid detection of microbial contaminants is of critical importance from biomedical, environmental, and security points of view. Such detection can be carried out by biosensors or by bio-analytical protocols for “real-time” identification (Leonard et al., 2003). Employment of biocompatible and suitable nanomaterials has given rise to the new term ‘nanobiosensor’, a technology that can contribute significantly towards improving the quality of human life (Nehra and Pal Singh, 2015; Singh et al., 2017).

Nanomaterial-based electrochemical biosensors are currently receiving a lot of attention from the research community on account of their sensitivity, selectivity, low cost, and capabilities for rapid detection (Ahmed et al., 2008; Pandey et al., 2008; Valentini and
Palleschi, 2008; Willner et al., 2007). The unique physicochemical properties of various types of nanomaterials, such as gold nanoparticles (AuNPs), carbon nanotubes, metallic oxides, and semiconductors have been employed (Hsing et al., 2007; Pingarrón et al., 2008; Rivas et al., 2007; Vastarella and Nicastri, 2005) in integrative designing of biosensors for medical and environmental purposes of and food quality monitoring. Among these, AuNPs especially possesses unique properties and provides a suitable microenvironment for immobilization of biomolecules while retaining their biological activity. This metallic nano-entity has enabled construction of a biosensor with enhanced efficacy and sensitivity compared to other bio-analytical devices. It facilitates signal between the immobilized proteins and electrode substrates (Hsing et al., 2007; Jia et al., 2008; Li et al., 2007; Yang et al., 2007). Moreover nanowire, (Chen et al., 2011; Pui et al., 2011, 2009) CNT (Huang et al., 2010b; Sorgenfrei et al., 2011; Sudibya et al., 2009) and SWCNT based (Agarwal et al., 2010; Villamizar et al., 2008) nanoelectronic diagnostic devices provide a quicker and more sensitive platform for pathogen detection.

Furthermore, graphene and related materials along with their compounds such as GO, GO exfoliated platelets and mono-multilayer-graphene (Gao, 2015; Loh et al., 2010; Unarunotai et al., 2010) have received vast amount of attention in the last couple of years (Allen et al., 2010; Rao et al., 2010, 2009; Soldano et al., 2010). The interesting and exciting properties such as chemical tunability of graphene-based nanomaterials have accelerated the pace of research yielding a vast body of literature on their potential applications (Zhu et al., 2010a). Heterogeneous electron movement between graphene-based nanomaterials and the molecule in the solution takes place at the edges of the graphene-based nanomaterial or at deformities in the basal plane, making this nanomaterial an excellent fit as the biosensor to detect a large range of compounds, sensitively and selectively, using several recognition platforms (Pumera, 2011).

Since, Deng et al. (2016) demonstrated that the gold-coated quartz crystal microbalance (QCM) could mimic the process of Sauerbrey's method (Yao et al., 2011; Ying et al., 2008) at the nanoscale, similar ways for the characterization of biomolecules were developed directly towards analytical purposes. These methods pursue the phase of immobilization in the fabricated quartz surface (Deng et al., 2016; Tang et al., 2013, 2011). Even though this nanotechnology has got noticeable potential in biosensing of particular biomolecules according to their frequency-time (Gibbs et al., 2015; Jaruwongrungsee et al., 2015; Kumar Singh and Singh, 2015; Ogi et al., 2013; Prakrankamanant et al., 2013; Quang et al., 2014; Tang et al., 2013, 2011) or impedance-frequency (Gibbs et al., 2015) signatures, its utilization in the area of biosensing and medical devices at the nano scale has been impeded by the efficacy and fast response required for the detection, and by the demanding nature of experimental instruments.

Tang et al. (2011) showed that a QCM biosensor monitored concanavalin (conA) via phenoxy-derived dextran (DexP) biomolecules that were assembled with graphene nanomaterials coated on the quartz crystal probe through π-π stacking interaction. In this proposed biosensor, first, the biosensor probe was blown dry using nitrogen gas and then placed on the sensing device. After that, a graphene nano-layers solution (500 µL) with a concentration of 5.0 mg mL\(^{-1}\) was placed in the solution chamber at room temperature for 20 minutes. In this stage, the gold surface absorbed the graphene nano-layers, and an additional 500 µL of the DexP solution was added in the cell holder. It was observed that some DexP biomolecules interacted with the graphene nano-layers through π-π stacking and the frequency was recorded. Finally, 500 µL of ConA (15 µL) was injected into the
cell holder and the change in frequency was recorded corresponding to the basic frequency. It had a low detection limit (5.0 μM of glucose) in the range of 0.01 to 5:7 mM at 3σ (Tang et al., 2011). Further, Zhihua et al. fabricated a novel graphene-coated QCM biosensor, with a correlation coefficient above 0.996 for the sensing of formaldehyde in the range of 10 and 100 ppm (Zhihua et al., 2012). Tang et al. showed a different type of displacement QCM based on glucose immune sensing action plane for the detection of small biomolecular biotoxins, namely brevetoxin B, PbTx-2, (used as a model) with signal amplification on a graphene functionalized biosensing interface. In this sensor, the frequency was directly related to the concentration of the bio-analyte sample (PbTx-2), in a range of $1.0 \times 10^{12} - 10^{8}$ g.mL$^{-1}$, with a low detection limit of 0.6 pg.mL$^{-1}$ at the $3\sigma_{\text{blank}}$ level as well as a coefficient of variation. In other words, the intra- and inter-assay were down by 7.5% and 9.5%, respectively (Tang et al., 2013). Afterwards, Quang et al. demonstrated a method for the formation of graphene-coated monolayers on the gold surface of the QCM using the chemical vapor deposition process on Cu foil. This sensor has applications in room temperature sensing of volatile organic compounds (such as butanol, isopropanol, acetone, and ethanol). Furthermore, this proposed biosensor presented 90% improvement in the frequency for separating gas and air (Quang et al., 2014).

Subsequently, Yao et al. fabricated a new humidity biosensor, based on GO nanofilms, for the stability of QCM using an impedance analysis technique. In this biosensor, the fixture of the GO-based QCM biosensor was found to be significantly greater than that of the polymer-coated QCM biosensor at any humidity. Mainly focused on large humidity points, the advantage of the fixture of the biosensor according to QCM-GO is more vital in that the quality factor is nearly 25 times higher than that of the polymer-coated sensor (Yao et al., 2014). Further, Balashov et al. fabricated newer symmetric surface acoustic wave humidity biosensors to form GO nanolayers from very small droplets of the aqueous GO dispersion solution over the exposed surface of the symmetrical surface of the acoustic wave atomizer. This biosensor with the incubated GO-nano-layers recorded a wide range of relative humidity values and presented the signal amplitude in the long range of 1–40 kHz. In this biosensor, the kinetics of adsorption of the water molecules was modelled using the assumption that two independent methods of the first order of adsorption occur. Saturation amplitudes and rate coefficients for both processes were experimentally examined using LSQ fitting of the biosensor signal in the time domain for the nano-layers that had several numbers of depositions (Balashov et al., 2015).

Additionally, Gibbs et al. fabricated new biosensor nanomaterials, which are based on cross-attached oligosaccharide layers, for the detection of a α-amylase reaction in the long range of 0.08–8 U/ml. In this sensor, layers’ degradation was monitored using QCM and impedance quantifications as well. The coated-nano-layers acquired a more stable response of QCM, which provides a high SNR in the PBS solution when measuring the signals to α-amylase. However, mass modification and energy dissipation as a biosensor response can be observed when using the amylopectin sheets. Even though the activity-dependent change in impedance were noticed, it was verified that the impedance for sensing the degradation of the oligosaccharide sheets at low α-amylase concentrations since the sheets of impedance were barely stable in the PBS solutions (Gibbs et al., 2015). A large sensitivity flow-based immunoassay based on a gold-coated QCM surface has been recently reported by Deng et al. This functionalized the shortest route in the QCM without demanding covalent conjugation steps. This sensor presents considerably low, nonspecific protein adsorption and an active response for antigen detection, corresponding to simple avidin-coated biosensors. The development of the biosensor fabrication and assay perfor-
mance takes ~ five hours in total, on par with or lower than graphene and GO-coated methods (Deng et al., 2016). In the present study, we exploited the current progress in surface modification of QCM to present operating the principle of a newer biosensing technique, based on an *E. coli* driven valve at the sub-nanometric scale.

The development of a novel biosensing concept implied various technical difficulties in its implementation. The improvement of every single component of the tool was carried out in accordance with the final project arrangement. This included the production of an *E. coli* with anti-β-gal complex suitable for interaction of GO nanosheets; the application of the quartz crystal cell as detector meant developing it together with the research to apply quartz crystal microbalance as manipulator; the development of the GO nanosheets based quartz surface detector had to be carried out in accordance with *E. coli* and anti-β-gal complex and with QCM setup. The deeply selective recognition process of *E. coli* hybrids is at the basis of this biosensor operation. The antibodies-antigens hybridization of *E. coli* was used in the project setup as frequency activators.

**5.2. INFRARED SPECTROSCOPY BASED BIOSENSING**

Infections caused by pathogenic bacteria pose serious health problems worldwide; these pathogens are often borne by sources such as water, soil and food (Alteri and Mobley, 2012; Karavolos et al., 2013; Mainil, 2013; Ooka et al., 2012; Tu et al., 2009). The conventional bacterial detection methods (Iqbal et al., 2000; Lazcka et al., 2007) are mostly based on (i) culture and colony counting methods (which involve counting of bacteria) (Brooks et al., 2004) (ii) immunology-based methods (which involve antibody-antigen interactions), (Akanda et al., 2011) and/or (iii) the polymerase chain reaction (PCR) method (which involves DNA analysis), all of which demand highly skilled manpower or long span of time up to 7 or 8 days to yield a diagnosis (Huang et al., 2010a). Further, currently available methods are limited by the lengths of assays and their sensitivity.

Recently, Hromadka et al. fabricated an array of three long period gratings (LPGs) in a single optical fiber and multiplexed it in the wavelength domain; this array was employed to simultaneously detect temperature, relative humidity, and volatile organic compounds, which are all focused indoor air quality indicators. Each LPG biosensors was shaped with an optimal response to a specific measure. In the proposed biosensor variants with no surface modification, modified by a mesoporous coating of silica nanoparticles (SiO$_2$NPs), and modified with a coating of SiO$_2$NPs infused with a functional material respectively, p-sulphanatocalix[8]arene (CA[8]) was used to detect temperature, relative humidity and the concentration of volatile organic compounds. The biosensors were developed with periods such that they worked at or near the phase matching the turning point. The average differences between values acquired by the optical fibre biosensor and standard temperature and relative humidity biosensors were greater than 0.5°C and 5% respectively. Further, the potential application of fibre optic sensors for detection of volatile organic compounds at high concentrations has been demonstrated (Hromadka et al., 2017). Novikov et al. reported a new gas biosensor for environmental sensing of nitrogen dioxide (NO$_2$) in the range of part-per-billion. This biosensor is based on epitaxial graphene on SiC surface and acquires a strong and reproducible signal from NO$_2$ for concentrations in the air down to one part-per-billion. Furthermore, this device was converted into a prototype of a portable system for environmental sensing that utilizes a mixture of sample gas exposure at room temperature and recovery of the sample at elevated temperature. This prototype sensor permits quick and reproducible tests of NO$_2$ concentration in high ranges for envi-
environmental pollution such as 5 ppb–50 ppb (Novikov et al., 2016). Andersen et al demonstrated that the proliferated use of modified nanomaterials, e.g. in nano-medicine, calls for newer methods that enable quick and sensitive analysis of minute samples. Here this sensor demonstrates nano-mechanical IR spectroscopy (NAM-IR) for chemical analysis of modified nanomaterials in picograms concentration. Modified nanomaterials are nebulized directly from the dispersion and collected without difficulty on nano-mechanical string resonators through a non-diffusion limited sampling technique. In this sensor, even minimum quantities of sample can change the absorbed IR light into a detectable frequency detuning of the string via photothermal heating. So, absorption IR spectrum is readily acquired by recording this detuning of the resonator over a range of IR wavenumber. Results recorded using modified nanomaterials-IR agree good with corresponding results acquired via ATR-FTIR, and remarkably, the test including sample preparation takes only a few minutes, compared to approximately two days that sample preparation takes for ATR-FTIR (Andersen et al., 2016).

Therefore, scientists have been dedicating significant amounts of time to invent detection devices for rapid screening of pathogens; biosensors appear to be the most promising systems among other detection tools. The biosensors (also referred to as immunosensors), are based on the principle of highly specific antibody-antigen recognition, and have been widely used for sensitive and quantitative detection of disease-related proteins, a critical tool for biomedical research and diagnostics (Artiles et al., 2011; Kuila et al., 2011; Liu et al., 2011b; Liu et al., 2010; Rijiravanich et al., 2008). In recent years, highly sensitive biosensing materials have been explored to enhance the detection limits of the pathogens in samples (Bonanni et al., 2014). Here, we made use of the recent advances in GO nanolayer coated on nanoporous PCTE membrane manufacturing to demonstrate the operating principle of a newer biosensing technique, based on an IR intensity driven valve in the sub-nanometric scale.

The development of a novel biosensing concept implied the need to solve several technical difficulties along its implementation. The development of every single part of the FTIR instrument was carried out in accordance with the project setup. This included: the production of an antibodies-antigens complex suitable for GO nanolayer coated PCTE transmembrane interaction; the development of the membrane cell holder in FTIR instrument as detector together with the IR detector as manipulator; and the development of the detector to record the change in the IR peaks in accordance with the corresponding antibodies-antigens complex.

### 5.3. NANOPORE BASED BIOSENSING

The marked scaling down in the costs of biosensing molecules has facilitated recent scientific analysis and promoted quick advances in the medical research fields. The development of a versatile, widely appropriate biosensor mechanism would be beneficial to the endorsement of these efforts. Ideally, a general biosensor should be able to detect all biomolecules and calculate their concentration at the same instant/moments, without any modification in the chemical environment or requirement for additional instrumentation. Among nanobiosensors that have shown potential for label-free single biomolecule sensing, one candidate that has drawn considerable attention is resistive pulse-biosensing using nanopore (Keyser, 2016; Lander et al., 2001).
The historical background of nanopore technology goes back to the year 1958 when the Coulter Counter for the counting of blood cells was invented. However, the approach didn’t gain much attention of the scientific community (Cornell et al., 1997; V’(ilwoulter, 1953). Further, Kubitschek and Kasianowicz et al. employed biological nanopore α-hemolysin to detect the translocation mechanism of DNA molecules. Modern nanopore technologies have been initiated by the transport of material particles to the opposite side of the cell membrane fully aided by channel proteins (Kasianowicz et al., 1996; Kubitschek, 1958). One apparent reason this method gained widespread attention was the directness of the approach.

Nanopores, with wide ranges in the order of nanometers, and of biological, polymer, graphene, GO, or hybrid (biological with synthetic matrix) origin have shown potential applications in the field of sensing, energy conversion, filtration and nanofluidic and physiological devices (Bell et al., 2012; Liu et al., 2016; Xie et al., 2011). These small apertures are generally found in membranes of either biological or synthetic nature. The nanopore-based analysis is an emerging label-free and amplification-free technique that involves the use of electrochemical gradients to force molecules through nano-scale pores present in a membrane matrix between two different electrolytes, and monitoring the ionic current modulations through the nanopore as molecules pass through it. This approach permits charged polymers including ssDNA, dsDNA, and RNA with a sub-nanometer resolution to be detected while avoiding the use of labels or necessity of signal amplification. Advancement in nanotechnology based sequencing technologies suggests that nanopore-based sensing devices could offer highly competitive advantages as compared to other third-generation sequencing technologies. In the past few years, biological and solid-state nanopores have been moving rapidly closer to the aim of direct, label-free sequencing of nucleic acid molecules in real time. There is no doubt that nanopore-based sensors/biosensors are potent candidates that can unite other third-generation sequencing technologies towards affordable and personalized DNA sequencing/biomolecules detection (Venkatesan and Bashir, 2011; Wang et al., 2014a).

Conventional sensing and sequencing technologies seem potentially less promising due to time-consuming, expensive reagents, a variety of labelling methods, varying pore size, and complicated membrane matrices in terms of size and thickness which affect the amperometric/potentiometric character of devices. This discussion inherently captures the applications of a variety of synthetic and naturally occurring nanopore-based functional devices employed as a versatile sensing design for monitoring a vast range of biologically complex interactions occurring in the proximity of lumen of the nanopore and immediately outside their outer surface modified with many functional groups bearing reagents. In contrast to conventional sensing devices, nanopore-based sensing technology has shown characteristics such as rapid, sensitive detection; it enables label-free, real-time, and sequence-specific, low cost, easy fabrication devices. Currently, graphene-based nanopores offer experimentally strong feasible technology for a new class of biosensing devices in terms of the lowest existing thinnest membrane matrix and an interlayer spacing (0.43 nm) of laminates that serve as nanocapillaries. This review reveals that nanopore-based devices seem to be potential candidates to lead sequencing technologies towards the next generation by way of providing convenient, affordable, and personalized means of sensing modality. Based on recent trends in graphene-based nanosieve and nanochannels for different biosensing devices and our current laboratory observations in this field, there is adequate evidence that such nanoplatform will play key roles in a coming couple of years in the sequencing and sensing technologies.
When a voltage is applied, ions move through the nanopore under the influence of the electric field, generating a stable open-pore current. When a strand of DNA translocates across a nanopore, the nanopores are partially blocked thereby decreasing the ionic current. Therefore, translocation events can be detected by the transient decrease of the ionic current (Gu et al., 2014; Maitra et al., 2012). Improvements in the nanoscale sensing lead to the advancement of fabrication techniques, which in turns helps to develop devices bearing channels and pores with reproducible dimensions and in a variety of materials. Variation in conductance during accumulation or instantaneous passage of ions in the through the channel/pore can be used to detect the analyte of interest. These biosensing devices take advantage of phenomena at the nano level, such as ion current rectification, surface conductance, and provide insight into properties of the targeted analytes. Ultimately these biosensing devices can be used to detect a variety of analytes such as ions, small molecules, proteins, nucleic acids, and particles (Harms et al., 2015). Biosensors use two types of detection techniques, which are classified as label-free detection and label based detection. In label-based detection, the detection of an analyte of interest relies on the use of specific properties of labels. In contrast, the label-free detection approach uses a strategy to detect analytes that are not labeled as well as to screen such analytes where tagging is not an easy task. A wide range of label-free biosensors have been developed within a past decade owing to the exponential growth of both nanotechnology and biotechnology (Nehra and Pal Singh, 2015; Sang et al., 2015).

Graphene, a recently discovered two-dimensional thin, flexible carbon lattice has been attracted widespread attention as a platform with excellent potential for the sensing of a variety of gases and molecules. Due to its unique electronic and mechanical properties, the nanopores can be ideally fabricated. Graphene nanopores are drilled via focused electron beams inside the transmission electron microscope. Molecules present in the electrolyte solution are driven through these nanopores. Suitable use of graphene nanomaterials as a membrane open up avenues for a new class of nanopore devices that allow both electronic sensing and control to be performed directly at the pore interface. Following the translocation of the molecules, the flow of ions is blocked which could be detected as a drop in the measured current.

Merchant et al. demonstrated the possibilities of graphene-based nanopore devices by utilizing nanopores created inside graphene membranes for the purpose of DNA translocation. They visualized larger current blockages as compared to traditional solid-state nanopores due to the thin nature of the graphene layer (Merchant et al., 2010). Min et al. theoretically reported an approach where fluidic nanochannel device with embedded graphene works as an extremely ultrasensitive platform to control the movement of the bases of the DNA via π-π interaction coupled with the conductance characteristics of the nanoribbon, for different bases to be distinguished one by one in real time using data mining technique and a 2D autocorrelation analysis (Min et al., 2011).

Puster et al. also reported the use of sensitive graphene nanoribbon (GNR) based nanopore devices for detection of DNA by preventing the TEM induced electron-beam damages (Puster et al., 2013). Avdoshenko et al. developed theoretical framework for DNA translocation by modeling using the dynamic and electronic transport analysis properties of graphene nanopore-based sensing device. Their findings reveal that, although is it not possible yet to distinguish the four nucleobases, one can have full control on the translocation dynamics if fourfold layers are deposited onto the graphene platform bearing pore. Several groups (Garaj et al., 2010; Puster et al., 2013; Schneider et al., 2010) have recently
realized and demonstrated experimentally the use of graphene sheets to fabricate nanopores and use them as a sensing device for detecting electric-field-driven translocation. Sathe et al. utilized molecular dynamics simulations as a computational investigatory method to reveal the translocation kinetics of a nucleic acid along with the magnitude of the ionic current blockages associated within graphene nanopores. Since graphene is a subnanometer thick material, the designing of graphene nanopore-based device can be directed to understand the influence of certain factors associated with the blockage of ionic current signals rooting from translocation phenomena (Sathe et al., 2011).

Nelson et al. proposed a single graphene nanochannel nanopore device that included two essential parameters for device performance simultaneously. This device, based on GNP, excludes the independency of the conductance to nucleobase orientation while passing through the nanopore as in the case of tunneling currents. Secondly, the device provides precise and sufficient data for discrimination of individual bases, presenting strong proof for their sensitive behaviour over ionic and tunneling currents (Nelson et al., 2010). You et al. made use of graphene layer with its reduced counterpart rGO layered membrane to achieve 100 % desalination and suggested that the membrane layer formed from graphene elegantly achieved the same attributes since the fabrication of rGO and its precise pore size control seemed to be very convenient and economical from the practical aspect in several industrial based filtration processes (You et al., 2016).

A derivative form of graphene, popularly known as GO, is expected to be a probable candidate due to several characteristics. Existing commercial technologies for providing fresh water for human consumption suffer from large energy consumption and high costs. Desalination with the aid of nanopore-based materials can surely help to overcome these problems (Yuan et al., 2014). Lin et al. explored the use of thin film membranes of reduced GO for the separation performance characteristic application in water desalination as well as CO₂ removal in natural gas purification, based on the direct relationship between the rGO synthesis parameters and the defect size. They reported that if appropriate synthesis conditions for the rGO membrane synthesis were selected it would be possible to gain excellent separation and identification of permeate fluxes compared to the available membranes (Lin and Grossman, 2015). Kim et al. used a few ultrathin layers of GO membranes for desired CO₂ gas separation profiles. The following group found the transit of gases by means of even, thick layers of GO membranes at elevated transmembrane pressures. Furthermore, gas permeability can be modulated by changing the average GO sheet size. On the basis of these findings, it may be concluded that gas permeability via ultrathin GO membranes is strongly proportional to the enforced transmembrane pressure for a particular average size of GO sheet (Kim et al., 2013a). This review encompasses the trends in the evolution of nanopores as sensing and sequencing devices and explores their suitability as third generation sequencing techniques with employment of various kinds of nanoporous structures to be used for biosensing matrices/platforms.