Land Rover Discovery Maintenance and Upgrades Manual, Series 1 and 2

Assembly Automation. Land Rover chooses hydroformed structure for Discovery 3 chassis frame. Engineering & Technology. Classic projects: Land Rover Series 1. JurPC. OLG Hamm, Beschluss vom 02.07.2015, 28 U 46/15. Keine Speicherung von Navigationsdaten im Land Rover Discovery. SAE Technical Paper Series. Torsion Mode Achievement on BIW of Next Generation Land Rover - Freelander. Progress in Vehicle Aerodynamics and Thermal Management. The Aerodynamics Development of the New Land Rover Discovery. Veterinary Record. Veterinary Record. Series III land rover - the go-anywhere vehicle. Auto Tech Review. Auto Tech Rev. Land Rover Discovery Sport HSE Luxury: Dynamic by design. Handbook of Large Hydro Generators. MAINTENANCE PHILOSOPHIES, UPGRADES, AND UPRATES. SAE Technical Paper Series. Integrating Simulation and Test to Develop the Aerodynamics of the New Land Rover Defender.

Meeting customer expectations along with regulatory requirements for efficiency and emissions reduction requires that even highly functional automotive products, such as 4x4s, are developed for aerodynamics efficiency. This is true of iconic vehicles, such as the Land Rover Defender. This paper discusses the redefinition of an icon: the aerodynamics development of the All-New Land Rover Defender. It outlines a strategy based on integrating simulation and test approaches: unsteady Computational Fluid Dynamics (CFD) simulation and Full-Scale Wind Tunnel testing. After outlining the integrated development model built around these toolsets, it demonstrates the natural fit between early phase work and simulation, where the focus was on optimizing vehicle volumes and proportions. The growing use of wind tunnel testing, as the design matures, is also explored, starting with full scale clay models before transitioning to a more representative bespoke test property. The overall development process is illustrated by exploring how the

need for a range of changes were identified and executed across a range of geometric zones and vehicle components is described, including: front bumper, body outboard corners, brake cooling ducts, profiled grille shutter vanes, trailing edge design, underbody, and wheel design.

. Journal of Quality in Maintenance Engineering. TPM implementation in Land?Rover with the assistance of a CMMS.
Details how Land?Rover was one of the leading companies in the UK to adopt total quality management (TQM). Shows that in order to provide both effective and efficient maintenance in accordance with TQM needs, Land?Rover (LR) reintroduced in 1994 total productive maintenance (TPM) in its manufacturing plant in Birmingham, UK. TQM is not possible without TPM so demonstrates how, in order to achieve its goals, TPM in LR is assisted by a computerized maintenance management system (CMMS). Describes in full the implementation steps of TPM, the difficulties encountered, and the usefulness and necessity of a computerized maintenance management system (CMMS) for the successful implementation of TPM in LR.

. SAE Technical Paper Series. Manual Maintenance Data Collection System for Lumber Industries Fleets. Government Publications Review (1973). Government Publications Review (1973). Classification manual for the OAS official records series: A manual for the maintenance of the series. Who's Who. Harper, Antony Peter, (born 23 May 1964), Director, Engineering Research, Jaguar Land Rover, since 2016. Harper, Antony Peter, (born 23 May 1964), Director, Engineering Research, Jaguar Land Rover, since 2016. Who's Who. Harper, Antony Peter, (born 23 May 1964), Director, Engineering Research, Jaguar Land Rover, since 2016. Harper, Antony Peter, (born 23 May 1964), Director, Engineering Research, Jaguar Land Rover, since 2016. SpringerReference. maintenance manual. Who's Who. Rogers, Nicholas Martin, (born 25 Dec. 1967), Executive Director, Product Engineering, Jaguar Land Rover, since 2015. Rogers, Nicholas Martin, (born 25 Dec. 1967), Executive Director, Product Engineering, Jaguar Land Rover, since 2015. Cranes. Maintenance manual. Who's Who. Rogers, Nicholas Martin, (born 25 Dec. 1967), Executive Director, Product Engineering, Jaguar Land Rover, since 2015. Rogers, Nicholas Martin, (born 25 Dec. 1967), Executive Director, Product Engineering, Jaguar Land Rover, since 2015

> *seventh national development plan 2017 2021 ib math sl binomial expansion worked solutions 2000 honda trx350tm te fm fe fourtrax service manual king why ill never stand again for the star spangled contrail service orchestration juniper networks*

SEVENTH NATIONAL DEVELOPMENT PLAN 2017 2021

Seventh National Development Plan 2017-2021: Questions and Answers

Q1. What is the Seventh National Development Plan (NDP)?

A: The NDP is a comprehensive framework that outlines Uganda's development priorities, strategies, and targets for the period 2017-2021. It aims to transform Uganda into a middle-income country by 2040.

Q2. What are the key priorities of the NDP?

A: The NDP emphasizes five key priorities: (1) Economic Transformation; (2) Poverty Reduction; (3) Human Capital Development; (4) Environment and Climate Change; and (5) Governance and Security.

Q3. How is the NDP being implemented?

A: The NDP is being implemented through a series of sector development plans and investment projects. The government is responsible for coordinating and overseeing the implementation process.

Q4. What are the expected outcomes of the NDP?

A: The NDP is expected to achieve the following outcomes by 2021:

- Increase in per capita income
- Reduction in poverty rates

- Improved access to basic services
- Reduced environmental degradation
- Strengthened governance and security

Q5. How is the NDP being monitored and evaluated?

A: The NDP is being monitored and evaluated on a regular basis using a set of indicators. The government is responsible for submitting progress reports to Parliament on a yearly basis.

IB MATH SL BINOMIAL EXPANSION WORKED SOLUTIONS

How do you get a 7 in IB math SL? In conclusion, achieving a 7 in IB Math AASL requires dedication, hard work, and effective study habits. By understanding the course requirements, developing strong study habits, practicing regularly, utilizing resources, and following test-taking tips, you can increase your chances of success.

What is the formula for binomial expansion IB? To find the 7th term in the expansion of (a + b)12, we can use the term formula for binomial expansion, which is given by T(k+1) = C(n, k) * a(n-k) * bk, where n is the power to which the binomial is raised, and k is the position of the term minus 1.

How to solve binomial theorem questions? The binomial theorem formula is (a+b)n= ?nr=0nCr an-rbr, where n is a positive integer and a, b are real numbers, and 0 r ? n. This formula helps to expand the binomial expressions such as (x + a)10, (2x + 5)3, (x - (1/x))4, and so on.

What is the formula for the binomial theorem Igcse? Binomial Expansion involving Linear Equation (a + b) n = a n + (n 1) a n ? 1 b + (n 2) a n ? 2 b 2 + … + (n r) a n ? r b r + … + b n , where is a positive integer and. r !

Is 5 out of 7 good in IB? IB grades are typically equivalent to certain numerical scores for academic purposes: A grade of 7 is equivalent to an A+ or 97-100% A grade of 6 is equivalent to an A or 93-96% A grade of 5 is equivalent to a B or 85-

92%

How rare is a 7 in IB? 1 in 5 students HL achieved a 7 in IB Physics exams You might have a one in five chance of getting a 7 in IB Physics HL, but you have a one in five chance of getting a two, three, four and five and six as well. So while this is good news, there's other facts that you should take into account there too.

How do you solve for binomial expansion?

What is the simplified formula for binomial expansion? The binomial theorem is a formula that can be used to expand a two-term expression raised to any power. The formula is: (x + y) n = ? k = 0 n (n k) x n ? k y k . This formula can be used to expand an exponentiated binomial or also be used to quickly identify a specific term within a binomial expansion.

How to do binomial expansion in a calculator?

What is the general formula for the binomial expansion? The binomial expansion formulas are used to find the expansion when a binomial is raised to a number. The binomial expansion formulas are: (x + y)n = nC0 0 xn y0 + nC1 1 xn - 1 y1 + nC2 2 xn-2 y2 + nC3.

What is the easiest way to solve a binomial problem? To solve a binomial problem, if your x term is being multiplied by a number, you'll divide both sides of your equation by that number. If your x term is being divided by a number, you'll multiply both sides of your equation by that number.

How do you solve a binomial step by step?

What is the formula for calculating binomial? The binomial distribution is given by the formula: P(X= x) = nCxpxqn-x, where = 0, 1, 2, 3, … P(X = 6) = 105/512. Hence, the probability of getting exactly 6 heads is 105/512.

What is binomial theorem basic formulas? In order to expand any binomial power into a series, the binomial theorem formula is needed. (a+b)n = ?nr=0 nCr an-r br, where n is a positive integer, a, b are real integers, and 0

Is binomial theorem hard? The binomial theorem is a mathematical formula that is used to perform extremely difficult and practically impossible calculations. Binomial theorems were used extensively in several of Sir Albert Einstein's equations, laws, and theories.

What is a 4.0 GPA in IB?

Is 70% a 6 in IB? 6 was awarded for 57-70 points in 2022 and 64-76 in 2023, and so on. Hence, we can't objectively compare 2023 IB results with recent years.

Is a 29 bad on IB? 24-29 - sub-average (28,30%) 30-34 - mediocre (26,95%) 35-39 - good (19,78%) 40-45 - very good (8,87%), 42+ can be considered outstanding.

What is the IB score for Harvard? A score within this range can strengthen your application, but remember, Princeton also values qualities like leadership, community involvement, and personal character. Harvard University's IB score range is 39-44.

What IB grade is a fail? Each IB subject is graded on a scale of 1 to 7, with 7 being the highest. To pass an individual IB subject, a student typically needs to score a 4 or above, but this can vary depending on the specific requirements of the Diploma Programme.

Is a 4 a bad IB score? Many universities often use a score of “4” or “5” as the minimum for granting admission or advanced placement.

Which number is larger 1.1 to the power 10,000? Thus (1.1)10000>1000. Q. Using binomial theorem, indicate which is larger (1.1)10000 or 1000.

Who is the father of the binomial theorem? Isaac Newton is generally credited with discovering the generalized binomial theorem, valid for any real exponent, in 1665.

What does n mean in numbers? The letter (N) is the symbol used to represent natural numbers. Natural numbers are also known as counting numbers, and they begin with the number 1 and continue to infinity (never ending), which is represented by three dots (...). The natural or counting numbers (N): 1, 2, 3, 4 . . . "and so on." Whole Numbers.

How to find n in binomial expansion?

How to calculate binomial expansion using a calculator?

How do you find the first three terms of a binomial expansion?

How to score a 7 in IB math?

What percentage is a 7 in IB math? IB Math Analysis and Approaches HL May 2022 only requires students to get an overall of 65% for a 7 while May 2023 will need 75%.

How do you get 7s in IB?

What is a 7 in IB equivalent to? In the higher level individual courses 7 is equivalent to A Level A* and 3 equivalent to E. In the standard level individual courses, 7 is equivalent to AS Level A and 3 equivalent to E. About 79% of Diploma students internationally are awarded the Diploma each examination session.

Is 70% a 6 in IB? 6 was awarded for 57-70 points in 2022 and 64-76 in 2023, and so on. Hence, we can't objectively compare 2023 IB results with recent years.

What is the hardest subject to get a 7 in IB? Attaining top grades in History HL can be particularly arduous, with only 3.7% of students achieving a score of 7. With a low rate of top grades, students often benefit from the guidance of an IB History tutor to enhance understanding and essay skills.

Is a 3 in IB bad? Each IB subject is graded on a scale of 1 to 7, with 7 being the highest. To pass an individual IB subject, a student typically needs to score a 4 or above, but this can vary depending on the specific requirements of the Diploma Programme.

What is a 75% in IB? A student scoring near 75 has achieved a “better” Grade 6 than one who scored near 65. To calculate the grade-decimal for Grade 7 results, the upper boundary would be the maximum mark achieved by an Australian IB student who has studied that subject.

What grade is 60% in IB?

How hard is it to get a 7 in IB math SL? Scoring a level 7 in IB Math is no easy feat. Many try but fail as it is one of the most difficult things to do. However, to all the ambitious and passionate students out there it is not impossible. It is all about putting in the effort, time, and consistency as only this will result in a 7 score.

What is the easiest subject to get a 7 in IB?

Is IB sl math hard? The subject delves into complex equations, abstract reasoning, and problem-solving techniques that can be quite demanding. Many students find it difficult to grasp the intricate concepts and navigate through the mathematical complexities."

How many students fail IB? Last May there were just over 85,000 students taking the IB diploma. Do you want to have a guess at how many were able to pass the IB? Although you might believe that the number is 50% or less, there was around a 78% pass rate in the IB last year! That's around 4 out of every 5 students who are able to pass.

Is IB harder than ap? Some students argue that IB is more challenging because of the emphasis on critical thinking and the more application-focused evaluations. However, both IB and AP classes are considered college-level courses that many students find challenging.

What IB score is needed for Harvard? Harvard University's IB score range is 39-44. While a high score can enhance your application, Harvard also looks for students who can contribute to their diverse community in unique ways.

Is 37 a bad IB score? Generally, an IB score of 38 and above is considered equivalent to AAA* at A-Level, which is often the requirement for entry into top-tier universities. A score of 34-37 in the IB is roughly equivalent to AAA at A-Level, and so forth. These comparisons are approximations and can vary by subject and university.

2000 HONDA TRX350TM TE FM FE FOURTRAX SERVICE MANUAL

Measurements of HF Concentrations Produced from Heptane/Air Pan Fires Extinguished by FE-36, FM-200, FE-36 Plus APP, and FM-200 Plus APP. . Facilities. Dalkia Workplace Services (formerly Symonds FM) seeking widespread user involvement in developing industry standard management manual for new facilities. IEEE Transactions on Magnetics. IEEE Trans. Magn.. High density recording on ultra-thin Fe-Pt perpendicular composite media. INTERMAG 2000 Digest of Technical Papers. 2000 IEEE International Magnetics Conference. High density recording on ultra-thin Fe-Pt films of perpendicular composite media. The Task Planner. Frontmatter. Journal of Manual & Manipulative Therapy. Journal of Manual & Manipulative Therapy. Service, Science and Self-Regulation: Refining the Values to Carry Us Forward. . Effects of the New FM 3-0 Operations (Final Draft) on Combat Service Support Planning Models. . Governance in the Twenty-first Century. Front Matter. Konstruktion. Frontmatter. Applied Physics Letters. Switching of the exchange bias in Fe/Cr(211) double-superlattice structures.

The reversal of the direction of the exchange bias in a “double-superlattice” system which consists of an Fe/Cr antiferromagnetic (AF) superlattice which is ferromagnetically coupled with an Fe/Cr ferromagnetic (F) superlattice through a Cr spacer layer, is observed. Magnetometry and polarized neutron reflectometry show that a switch in the bias direction occurs at a field (?447 Oe) well below the field (14 kOe) necessary to saturate the AF superlattice and well below the field (2 kOe) where the AF superlattice initiates a spin–flop transition. The switching of the exchange bias cannot be explained in terms of a model of uniform rotation, but rather by breakdown into domains and reversal of the AF layers. The transparency of magnetic behavior of the double superlattice may be useful in understanding the behavior of traditional exchange bias systems.

. ChemInform. ChemInform. ChemInform Abstract: T?x Phase Diagram of the In_2Te_3—$FeTe_2$ Join in the In—Fe—Te System..

ChemInform is a weekly Abstracting Service, delivering concise information at a glance that was extracted from about 100 leading journals. To access a ChemInform Abstract of an article which was published elsewhere, please select a “Full Text” option. The original article is trackable via the “References” option.

. Facade Construction Manual. Frontmatter. Urdu for Children, Book II, Teacher’s

Manual. Front Matter. Manual der Koloproktologie. Frontmatter. Manual der Koloproktologie. Frontmatter. Autisme: hoe te verstaan, hoe te begeleiden?. Advanced Materials '93. Film morphology and Fe-magnetization in Gd/Fe multilayers. Visible Light Communications. Visible Light Communications Solutions Manual. Manual de linguística portuguesa. Frontmatter

KING WHY ILL NEVER STAND AGAIN FOR THE STAR SPANGLED

The Uncrowned King of Swing. Never Say “Never Again”. Oxford English Dictionary. star-spangled, adj.. Star-Spangled Banner. Star-Spangled Soccer. Never Again. Why Don’t We Act?. The Diagonal Argument Strikes Again: Why Physical Systems Can Never Be Sure.

Chalmers has described the meta-problem of consciousness as the problem of understanding how and why we come to believe that we are conscious. Here we show that the meta-problem of consciousness is intimately related to another problem; the meta-problem of existence, or the problem of understanding how and why we come to believe that we exist. This problem is shown to lead to a version of Russell's paradox which makes it impossible for any physical system ever to be sure that it exists. The problem is illustrated by a thought experiment, the "sleepwalker paradox", which shows that no physical system can ever be sure that it is not in a dreamless sleep.

. Never Again Say “Never Again”.

“Never Again” is one of those slogans on which practically everyone can agree. How can one not? (Unless you belong to the flat-earth Holocaust-denial lunatic fringe). When we use “Never Again” it is, of course, a shorthand to the enormity of German National Socialism. The pledge “Never Again” is absolute in time: Never again. It is absolute in space too: “That” cannot and should not ever take place anywhere. It is universal: It bridges Left and Right, North and South, Rich and Poor. Standing at the barricades under the “Never Again” banner is both powerful and self-empowering. But herein lies its potential for abuse. What exactly is the “that” which must never happen again?

. Rudolph Ganz, Patriotism, and Standardization of The Star-Spangled Banner,

1907-1958. The Advocacy of the Immigrant – Ganz and The Star-Spangled Banner. Notes. Notes. Star Spangled Songbook: A History in Sheet Music of "The Star-Spangled Banner." eds. by Mark Clague and Andrew Kuster. Why Dogs Stopped Flying. GREAT SPANGLED FRITILLARY. Sean Connery. Never Say Never Say Never Again Again. Paul Robeson leads shipyard workers in singing the Star Spangled Banner. English Education. Why I'll Never Teach Grammar Again. What Is an Image?. I'LL NEVER SAY "NEVER AGAIN" AGAIN. Star Spangled Security: Applying Lessons Learned over Six Decades Safeguarding America. Aina Hanau / Birth Land. STAR-SPANGLED BANNER. Encyclopedia of War & American Society. "Star-Spangled Banner, The". The Prisoner's Dilemma. The inner struggle: why you should cooperate with people you will never meet again. Never Again – Ever Again.

The "Never Again" is the desperate evocation of something impossible. Nothing prevents people from expanding the arsenal of their crimes with ever newer, ever more artificial, more scientific methods and instruments, and from using them. Just as grass and flowers mercifully spread over the ruins of the ovens, the fields fertilized with ashes, all attempts to bear witness to the crimes, to keep memory alive as a warning, dissolve into the history of the victors, which has dominated everything else in all times of human history.

. Oxford Scholarship Online. Never Go Swimming Again. Never Go Swimming Again.

Steven Spielberg's Jaws (1975) terrified audiences through its convincing depiction of shark attacks off the coast of the New England island Amity. A great white shark terrorizes bathers, but local politicians refuse to acknowledge the danger, fearing a drop in tourism. The protagonist, Chief Brody, faces the truth and unselfishly attempts to save his community from the danger. This chapter argues that the power of Jaws to engage and disturb audiences comes from its success in immersing viewers in a primal scenario of predation by a malevolent monster, the shark, which meets the input specifications of evolved anti-predatory mechanisms in the human mind. The monster film compounds the fear of predation with the anxiety of uncertainty and sympathetic fear for protagonists in peril. We never know when the shark will strike, but we are alerted ahead of characters through aesthetic means, such as the film's soundtrack.

CONTRAIL SERVICE ORCHESTRATION JUNIPER NETWORKS

SpringerReference. Service Orchestration. Zero-touch service orchestration in 5G and beyond mobile networks.

(English) The expeditious growth and development of Beyond-5G and 6G networks inaugurated a new sector in the research of cellular networking. Automation and scaling are now considered a necessity to cope with the anticipated demand of the new high-performing communication networks. The current networks expand at a rate that creates an urgent pressure for Infrastructure Providers to adopt intelligent, AI-based technologies for automated network management and orchestration. This Ph.D. Thesis is dedicated to the development of an intelligent, automated and scalable service management and orchestration framework, that does not require human intervention to operate. Several experiments were conducted to modeland validate the use of the RL-based zero-touch management and orchestration algorithms under different conditions and settings. This Ph.D Thesis is divided into three main parts. The first part is dedicated to the new paradigm that modern beyond 5G and 6G telecommunications brought to society. Speed, reliability, and scale are now at the epicenter of the industry. The enabling technologies that allow reaching the promised Key Performance Indicators are discussed. Slicing, the main focus of Beyond-5G networks is introduced and analyzed from both technical and business standpoints. The second part of this dissertation is devoted to the automated management and orchestration of computing and network resources in 5G and beyond networks. A dynamic, resource-aware Virtual Network Functions placement AI-based algorithm is proposed and explained in detail. Later, an end-to-end data-driven service orchestration framework is proposed and discussed. A special vehicular Ultra-Reliable Low Latency Communications (URLLC) scenario is further explored to evaluate and demonstrate the performance of the proposed algorithms. The main focus of this part is the End-to-End average latency reduction for such services. Finally, in the third part is focused on the developed SCHEMA framework. A multi-domain, slice and service chain elastic management and orchestration framework.Three main variations of the proposed algorithm are explored, specifically on latency and energy reduction and most importantly on safe automated decision

making with distributed reinforcement learning.

(Català) El ràpid creixement i desenvolupament de les xarxes Beyond-5G i 6G va inaugurar un nou sector en la recerca de xarxes cel·lulars. L'automatització i l'escalat es consideren ara una necessitat per fer front a la demanda prevista de les noves xarxes de comunicació d'alt rendiment. Les xarxes actuals s'expandeixen a un ritme que crea una pressió urgent perquè els prove¨?dors d'infraestructures adoptin tecnologies intel·ligents basades en IA per a la gestió i l'orquestració de xarxes automatitzades. Aquesta tesi doctoral està dedicada al desenvolupament d'un marc d'orquestració i gestió de serveis intel·ligent, automatitzat i escalable, que no requereix intervenció humana per funcionar. Es van realitzar diversos experiments per modelar i validar l'ús dels algorismes d'orquestració i gestió sense toc basats en RL en diferents condicions i configuracions. Aquesta tesi doctoral es divideix en tres parts principals. La primera part està dedicada al nou paradigma que les telecomunicacions modernes més enllà del 5G i 6G van aportar a la societat. La velocitat, la fiabilitat i l'escala es troben ara a l'epicentre de la indústria. Es discuteixen les tecnologies habilitadores que permeten assolir els indicadors clau de rendiment promesos. Slicing, el focus principal de les xarxes Beyond-5G s'introdueix i s'analitza tant des del punt de vista tècnic com empresarial. La segona part d'aquesta tesi està dedicada a la gestió i orquestració automatitzada de recursos informàtics i de xarxa en xarxes 5G i més enllà. Es proposa i s'explica amb detall un algorisme de col·locació de funcions de xarxa virtual dinàmic i conscient dels recursos basat en IA. Més tard, es proposa i es discuteix un marc d'orquestració de serveis basat en dades d'extrem a extrem. S'explora un escenari especial de comunicacions de baixa latència ultra fiable (URLLC) per a vehicles per avaluar i demostrar el rendiment dels algorismes proposats. L'objectiu principal d'aquesta part és la reducció de la latència mitjana d'extrem a extrem per a aquests serveis. Finalment, en la tercera part se centra en el marc SCHEMA desenvolupat. Un marc d'orquestració i gestió elàstica de múltiples dominis, seccions i cadena de serveis. S'exploren tres variacions principals de l'algorisme proposat, específicament sobre la latència i la reducció d'energia i, el més important, sobre la presa de decisions automatitzada segura amb aprenentatge de reforç distribuït.

. End-to-end network service orchestration in heterogeneous domains for next-generation mobile networks.

5G marks the beginning of a deep revolution in the mobile network ecosystem, transitioning to a network of services to satisfy the demands of new players, the vertical industries. This revolution implies a redesign of the overall mobile network architecture where complexity, heterogeneity, dynamicity, and flexibility will be the rule. Under such context, automation and programmability are essential to support this vision and overcome current rigid network operation processes. Software Defined Networking (SDN), Network Function Virtualization (NFV) and Network slicing are key enabling techniques to provide such capabilities. They are complementary, but they are still in its infancy and the synergies between them must be exploited to realise the mentioned vision. The aim of this thesis is to further contribute to its development and integration in next generation mobile networks by designing an end-to-end (E2E) network service orchestration (NSO) architecture, which aligned with some guidelines and specifications provided by main standardization bodies, goes beyond current management and orchestration (MANO) platforms to fulfil network service lifetime requirements in heterogeneous multi-technology/administrative network infrastructures shared by concurrent instances of diverse network services. Following a bottom-up approach, we start studying some SDN aspects related to the management of wireless network elements and its integration into hierarchical control architectures orchestrating networking resources in a multi-technology (wireless, optical, packet) infrastructure. Then, this work is integrated in an infrastructure manager module executing the joint resource abstraction and allocation of network and compute resources in distributed points of presence (PoPs) connected by a transport network, aspect which is not (or lightly) handled by current MANO platforms. This is the module where the integration between NFV and SDN techniques is executed. This integration is commanded by a Service Orchestrator module, in charge of automating the E2E lifecycle management of network services implementing network slices (NS) based on the vertical requirements, the available infrastructure resources, and, while fulfilling service level agreement (SLA) also during run-time operation. This architecture, focused on single administrative domain (AD) scenarios, constitutes the first group of contributions of this thesis. The second group of contributions evolves this initial architecture to deal with the orchestration and sharing of NS and its network slice subnet instances (NSSIs) involving multiple ADs. The main differential aspect with current state-of-the-art solutions is the consideration of resource orchestration aspects during the whole

orchestration process. This is fundamental to achieve the interconnection of NSSIs, hence making the E2E multi-domain orchestration and network slicing a reality in practice. Additionally, this work also considers SLA management aspects by means of scaling actions during run-time operation in such complex scenarios. The third group of contributions demonstrate the validity and applicability of the resulting architectures, workflows, and interfaces by implementing and evaluating them in real experimental infrastructures featuring multiple ADs and transport technologies interconnecting distributed computing PoPs. The performed experimentation considers network service definitions close to real vertical use cases, namely automotive and eHealth, which help bridging the gap between network providers and vertical industries stakeholders. Experimental results show that network service creation and scaling times in the order of minutes can be achieved for single and multi-AD scenarios, in line with 5G network targets. Moreover, these measurements serve as a reference for benchmarking the different operations involved during the network service deployment. Such analysis are limited in current literature.

5G marca el inicio de una gran revolución en las redes móviles, convirtiéndose en redes orientadas a servicios para satisfacer las demandas de nuevos actores, las industrias verticales. Esta revolución supone un rediseño total de la arquitectura de red donde la complejidad, heterogeneidad, dinamicidad y flexibilidad serán la norma. En este contexto, la automatización y programabilidad serán esenciales para superar los rígidos procesos actuales de operación de red. Las redes definidas por software (SDN), la virtualización de funciones de red (NFV) y el particionamiento de redes son técnicas clave para proporcionar dichas capacidades. Éstas son complementarias, pero aún recientes y sus sinergias se deben explotar para realizar la nueva visión. El objetivo de esta tesis es contribuir a su desarrollo e integración en la nuevas generaciones de redes móviles mediante el diseño de una arquitectura de orquestación de servicios de red (NSO) extremo a extremo (E2E), que alineada con algunas pautas y especificaciones de los principales organismos de estandarización, va más allá de los actuales sistemas de gestión y orquestación (MANO) para instanciar y garantizar los requisitos de los diversos servicios de red desplegados concurrentemente en infraestructuras heterogéneas compartidas que combinan múltiples tecnologías y dominios administrativos (AD). Siguiendo un enfoque ascendente, comenzamos a estudiar aspectos de SDN relacionados con la gestión de elementos de red inalámbricos y su integración en arquitecturas

jerárquicas de orquestación de recursos de red en infraestructuras multi tecnología (inalámbrica, óptica, paquetes). Luego, este trabajo se integra en un módulo de administración de infraestructura que ejecuta de forma conjunta la abstracción y la asignación de recursos de red y computación en múltiples puntos de presencia (PoP) distribuidos conectados por una red de transporte, aspecto que no está (o ligeramente) considerado por los actuales sistemas MANO. Este módulo ejecuta la integración de las técnicas NFV y SDN. Esta integración está dirigida por el módulo Orquestador de Servicios, que automatiza la gestión E2E del ciclo de vida de los servicios de red implementando las diferentes particiones de red en base a los requisitos de los verticales, los recursos de infraestructura disponibles y mientras cumple los acuerdos de nivel de servicio (SLA) durante la operación del servicio. Esta arquitectura, centrada en escenarios con un único AD, forma el primer grupo de contribuciones de esta tesis. El segundo grupo de contribuciones evoluciona esta arquitectura abordando la orquestación y compartición de particiones de red y sus componentes (NSSIs) en escenarios con múltiples AD. La consideración detallada de aspectos de orquestación de recursos es el principal aspecto diferencial con la literatura. Esto es fundamental para la interconexión de NSSIs, haciendo realidad la orquestación E2E y el particionamiento de red en escenarios con múltiples AD. Además, se considera la gestión de SLA mediante acciones de escalado durante la operación del servicio en los escenarios mencionados. El tercer grupo de contribuciones valida las arquitecturas, procedimientos e interfaces resultantes pues se han implementado y evaluado sobre infraestructuras experimentales reales que presentan múltiples AD y tecnologías de transporte interconectando PoP distribuidos. Esta experimentación considera definiciones de servicios de red cercanos a casos de uso de verticales reales, como automoción y eHealth, ayudando a cubrir la brecha entre los proveedores de red y los verticales. Los resultados experimentales muestran que la creación y el escalado de servicios de red se pueden realizar en pocos minutos en escenarios con un único o múltiples ADs, en línea con los indicadores de red objetivos de 5G. Estas medidas, escasas en la literatura actual, sirven como referencia para caracterizar las diferentes operaciones involucradas durante el despliegue de servicios.

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